Space Weather Models running in real-time or forecasting mode

Yihua Zheng [1]

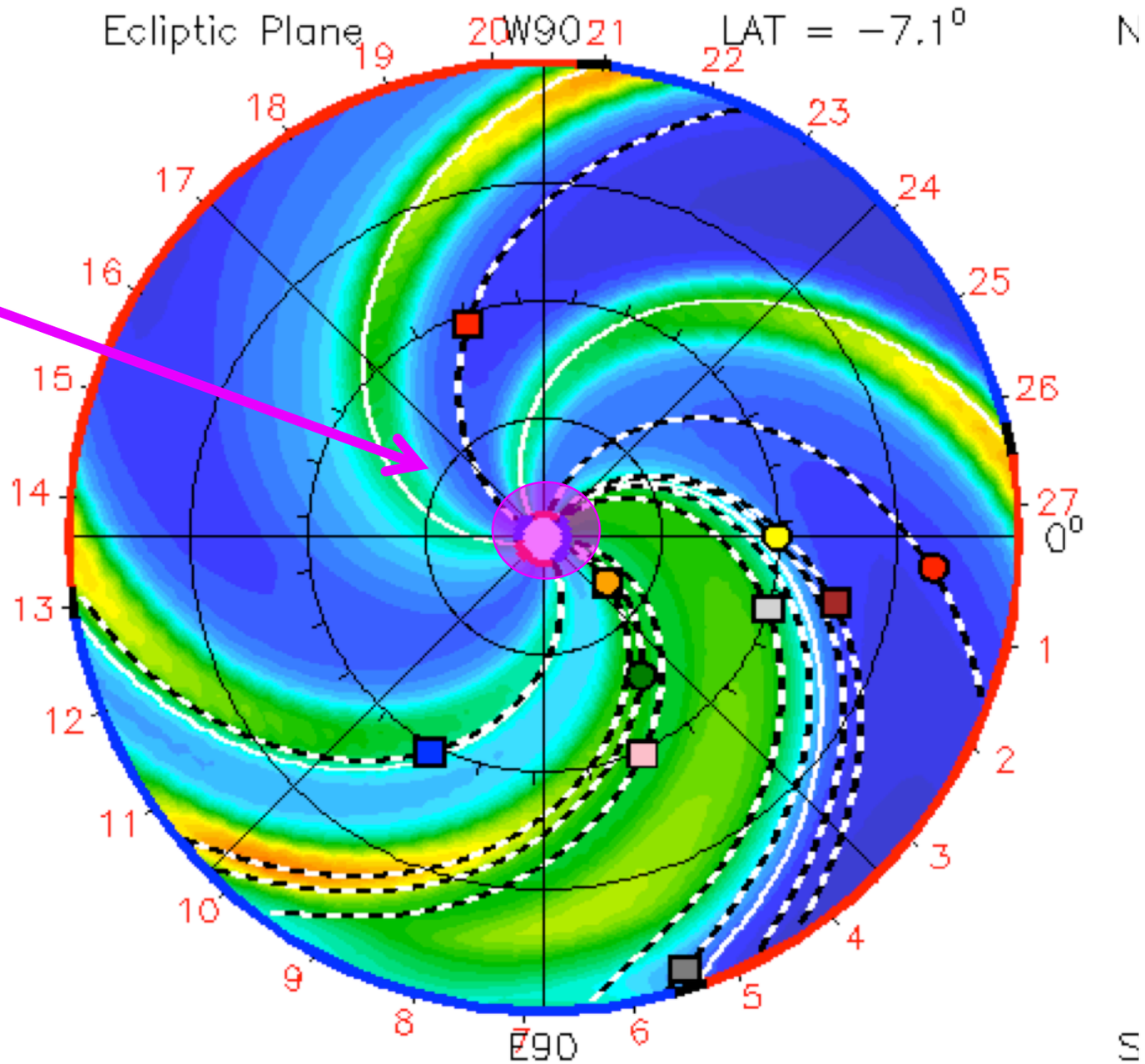
About WSA+ENLIL

The WSA+ENLIL Model Suite

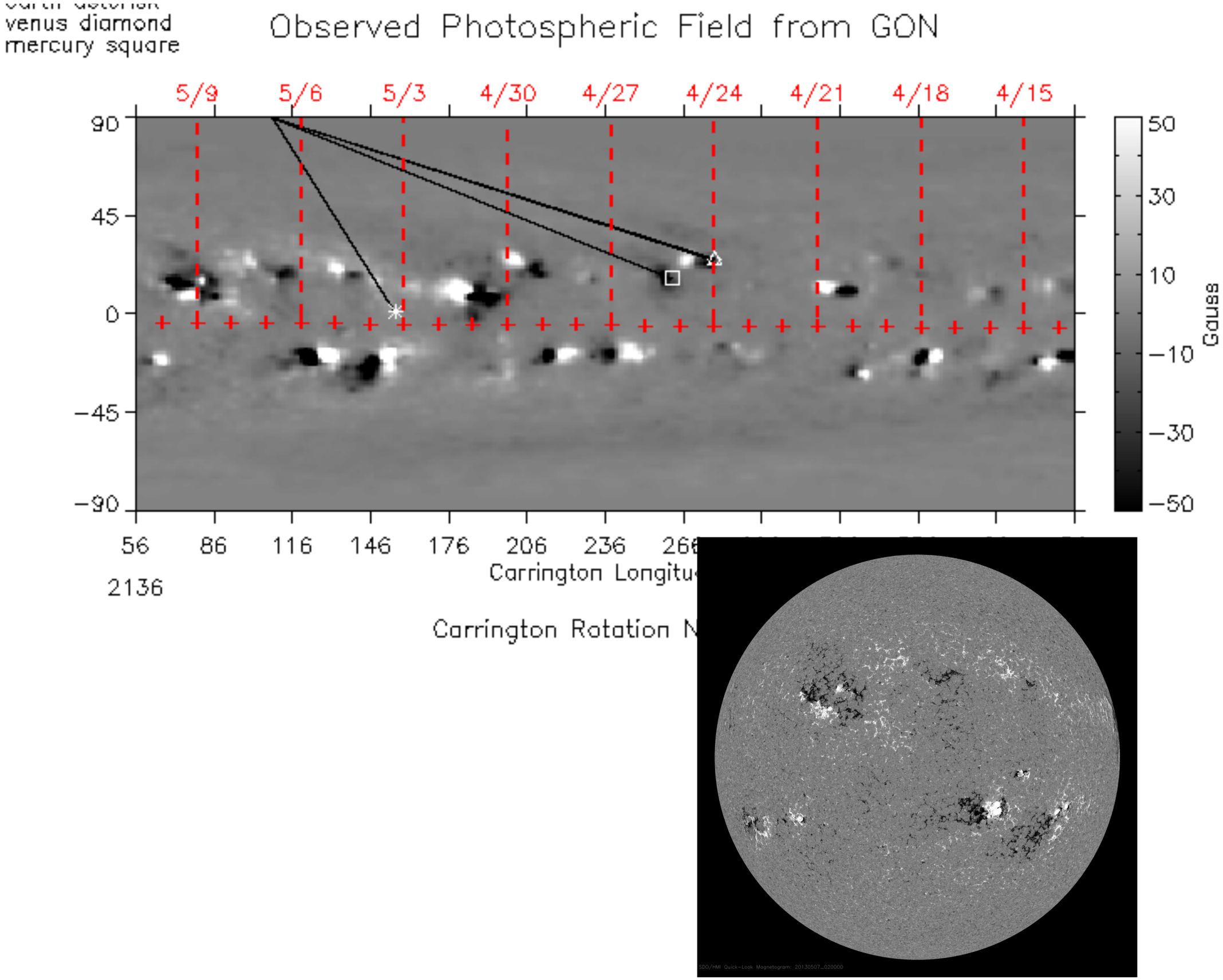
Wang-Sheeley-Arge (WSA Model)
1 Rs – 21.5Rs (0.0046 -0.1AU)

Photospheric magnetic field maps (can be from satellite observations such as SOHO/MDI or SDO/HMI or ground-based observations such as the GONG magnetogram) are used as input to the WSA model (model solar corona up to 21.5 Rs) to represent the ambient solar wind.

ENLIL: 0.1 AU – 2 AU (operations)



Model of the solar wind in the heliosphere

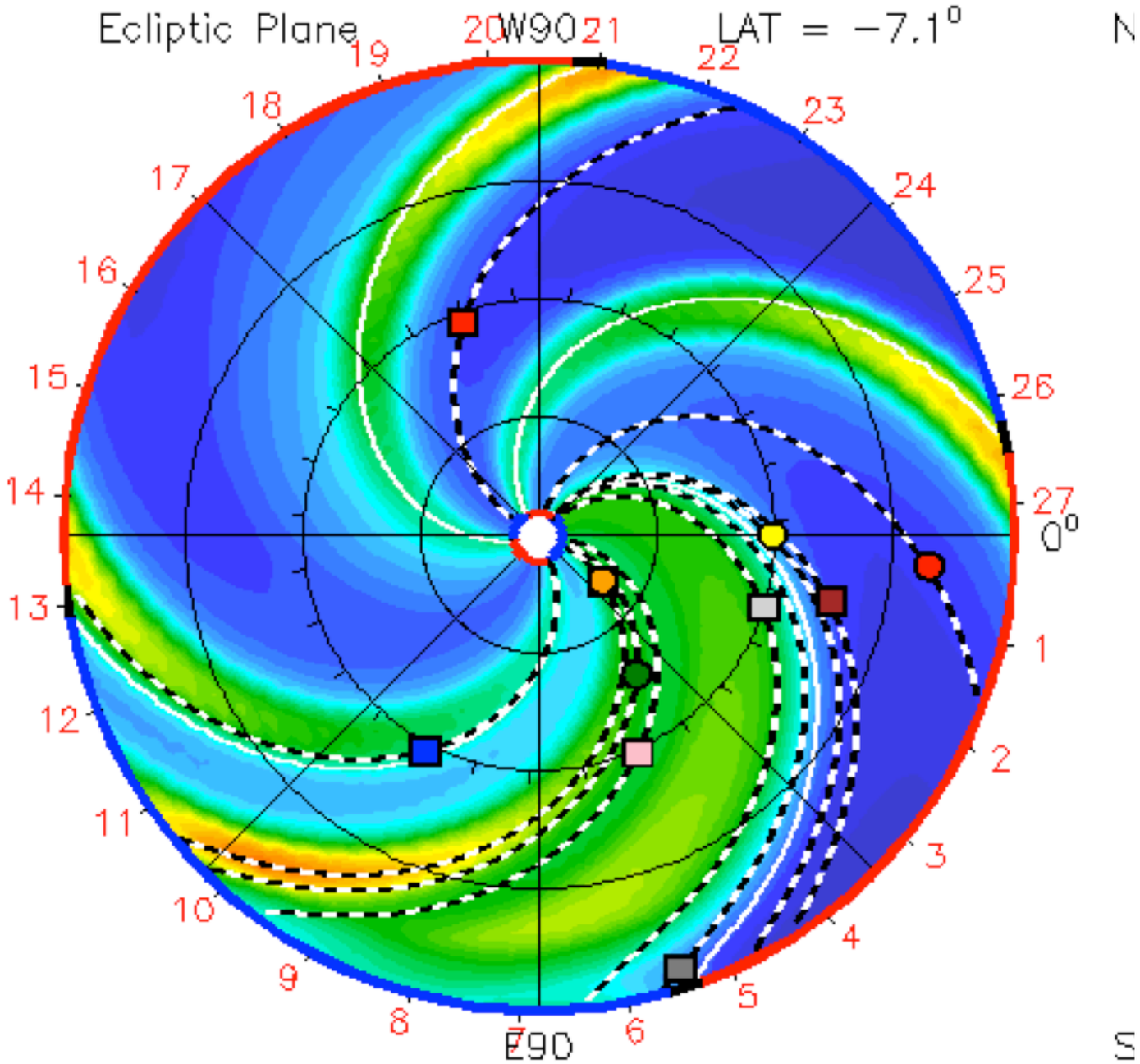

venus diamond
mercury square
Observed Photospheric Field from GON
5/9
5/6
5/3
4/30
4/27
4/24
4/21
4/18
4/15
90
45
0
−45
−90
50
30
10
−10
−30
−50
Gauss
56
86
116
146
176
206
236
2136
Carrington Longitu
Carrington Rotation N
SDO/HMI Quick-Look Magnetogram: 20130507_020000

EN = Lord + LÍL = Storm, "Lord (of the) Storm"

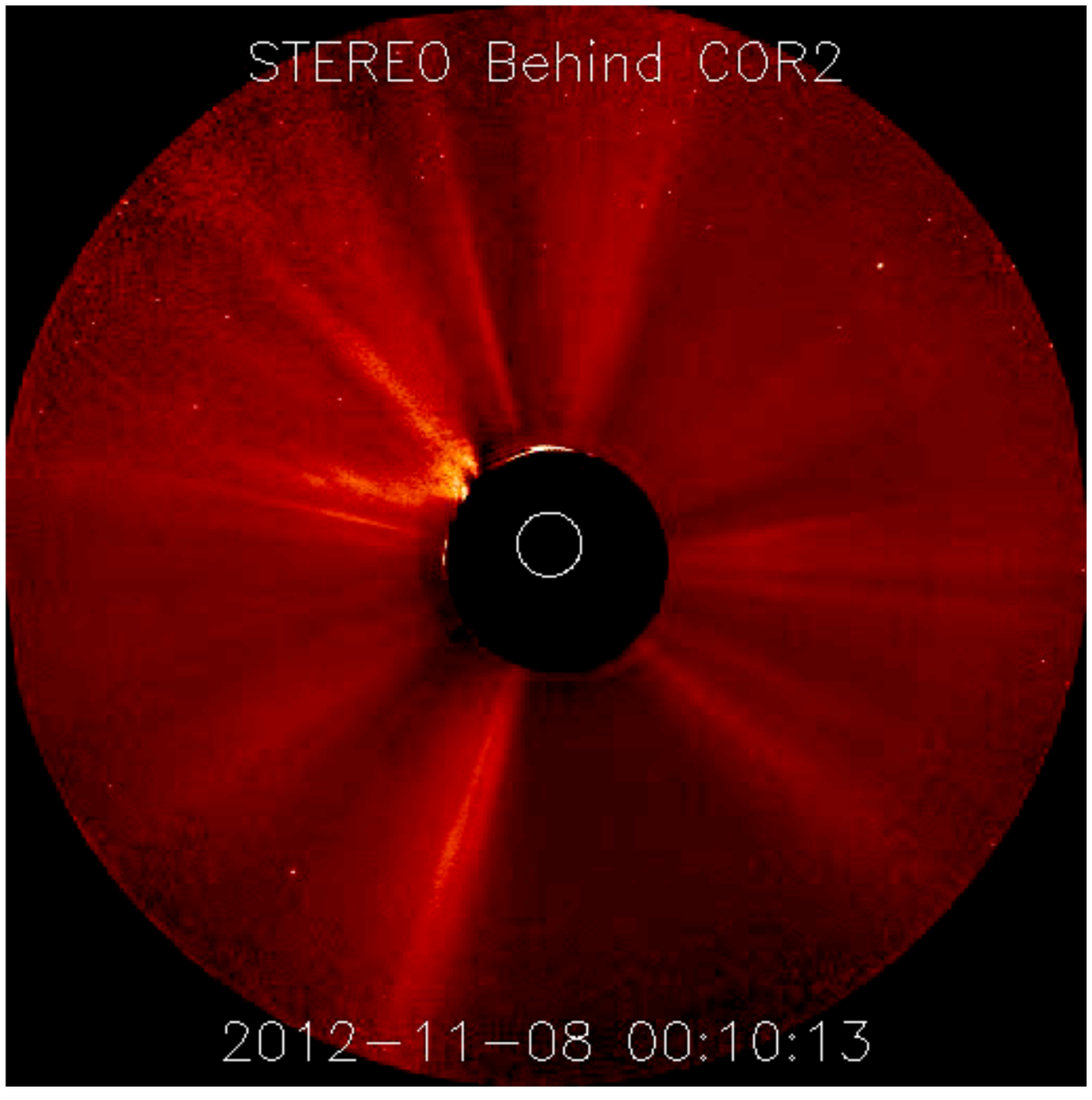
Courtesy: Dusan Odstrcil

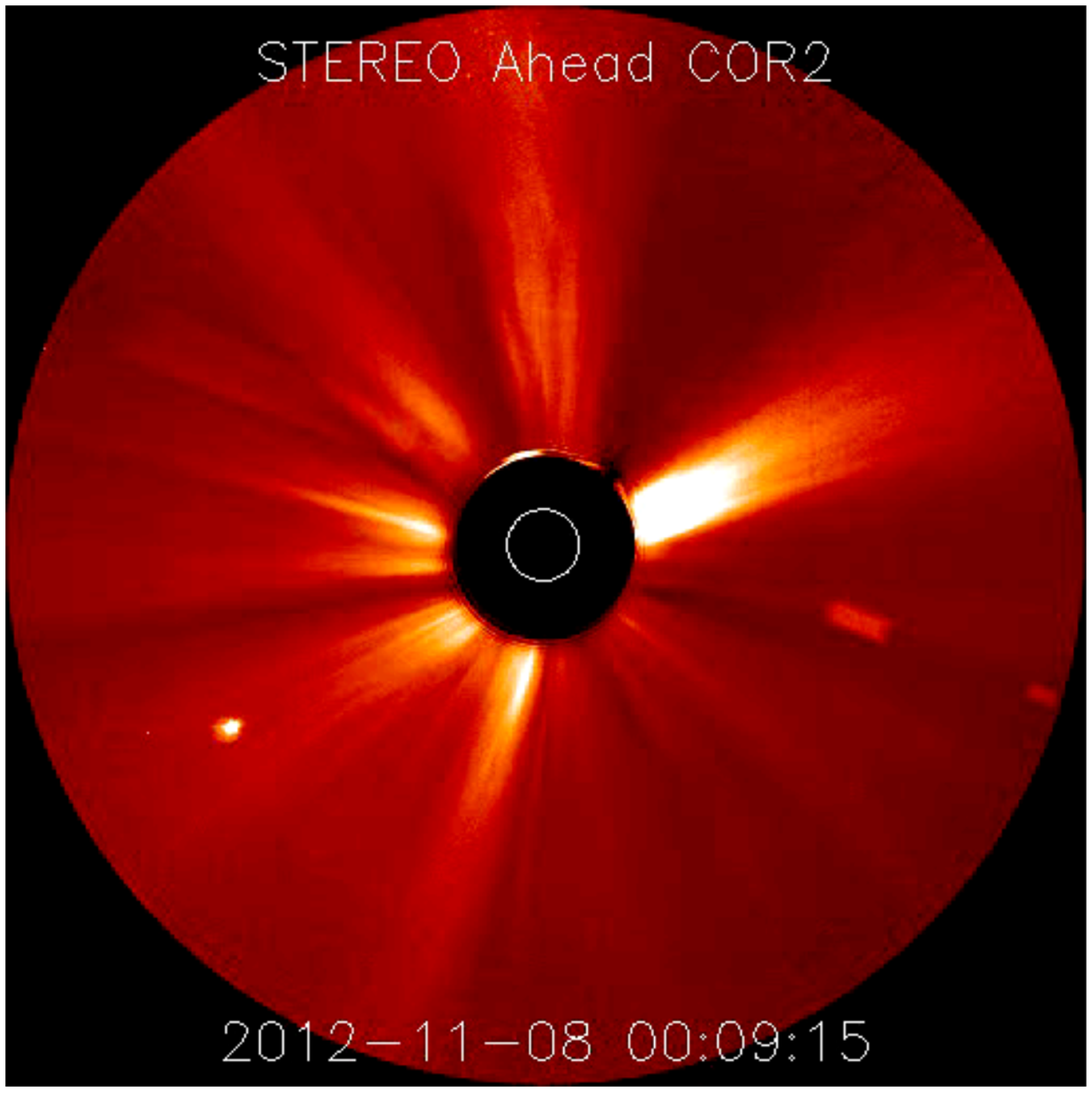
WSA+ENLIL: capable of modeling the solar wind for both ‘fair’ weather and ‘storm’ conditions

Fair weather: ambient solar wind

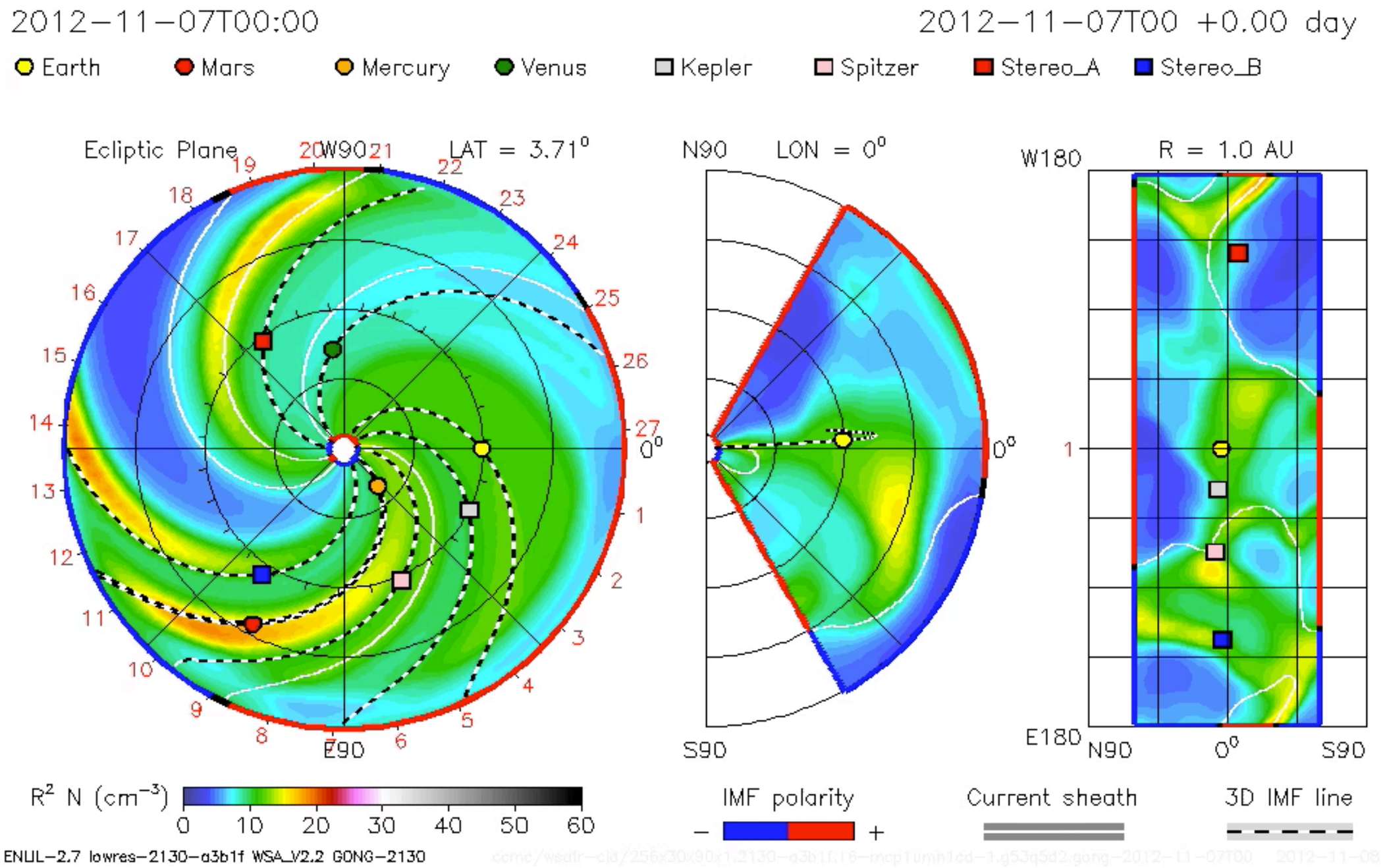


Stormy Weather: Eruptions (CME)

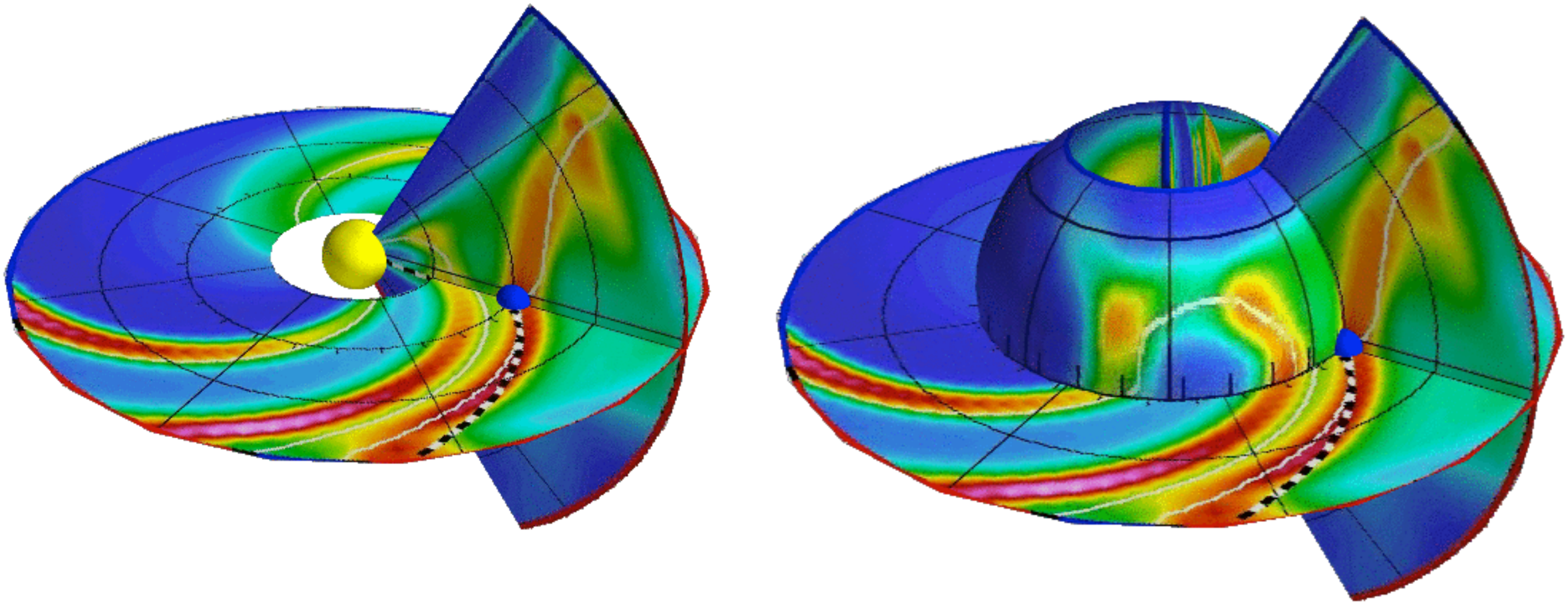




Modeling of solar wind under stormy conditions

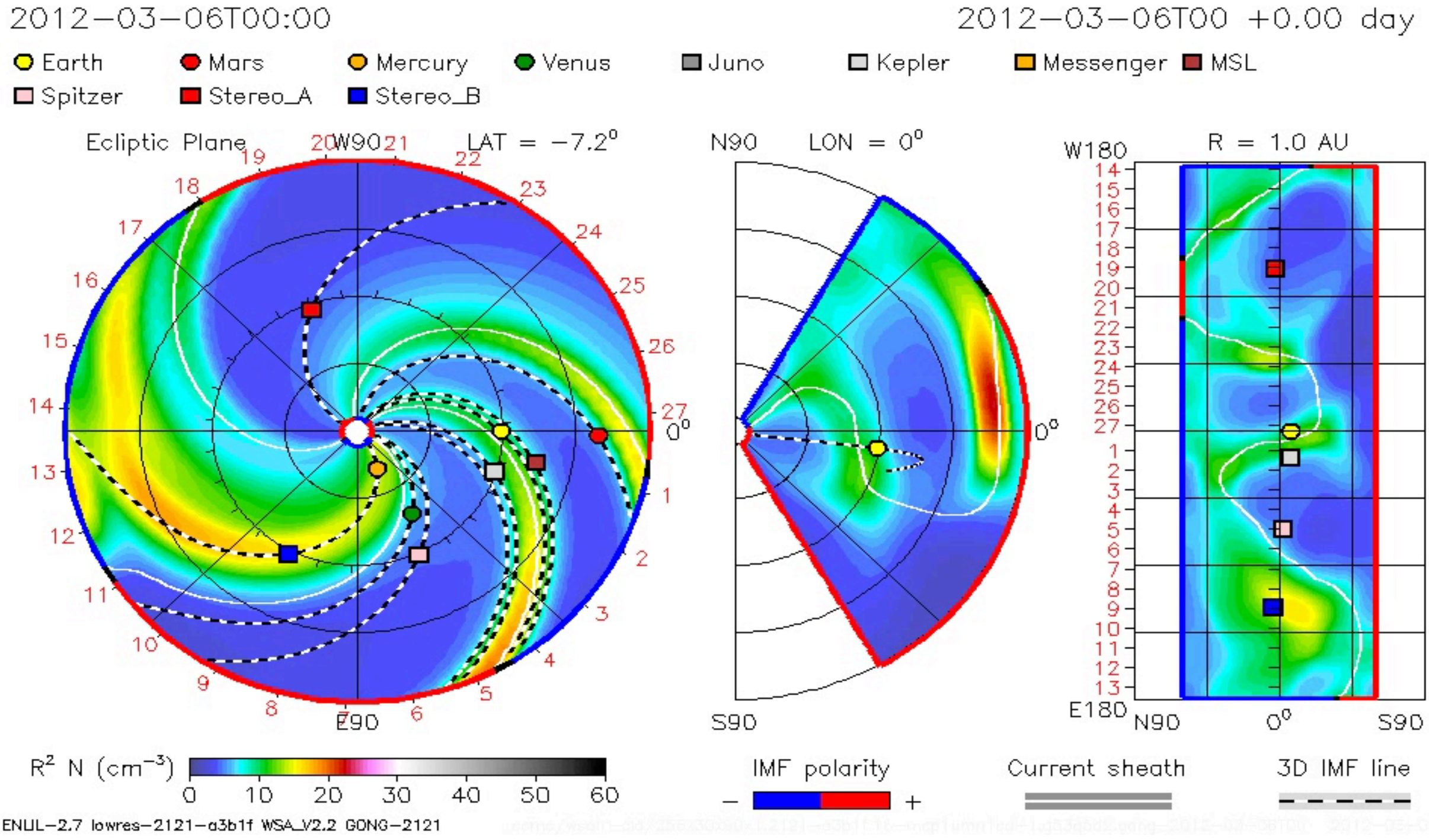


ENLIL Visualization

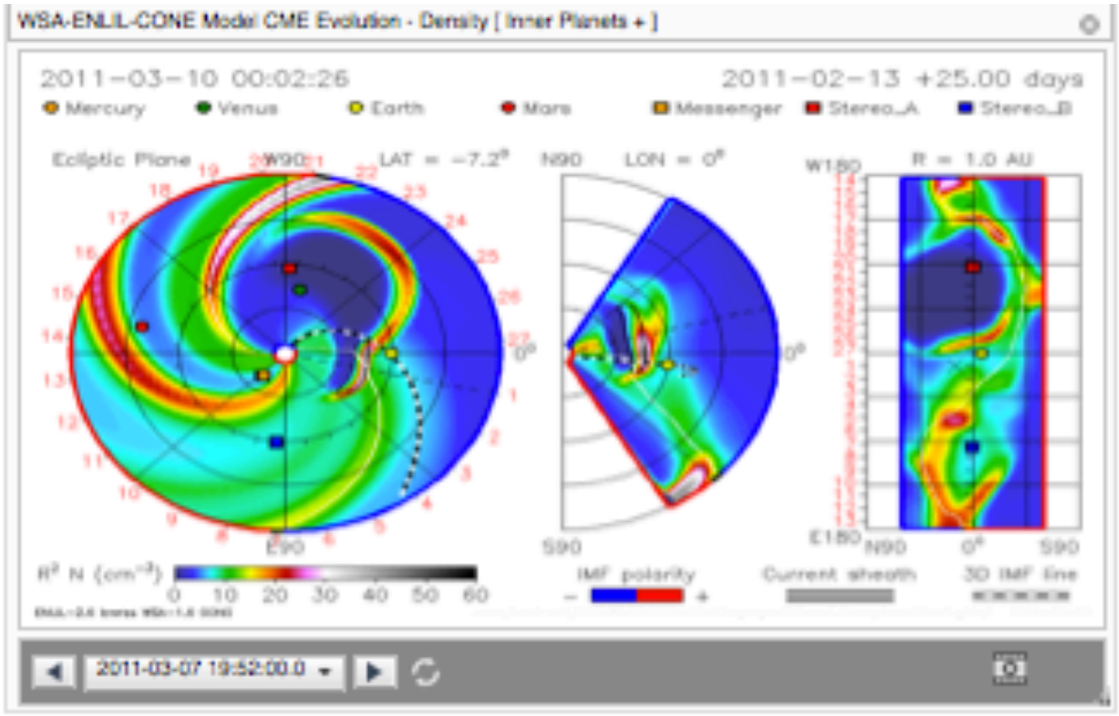


Courtesy of Stijn Calders @BIRA

Modeling of solar wind under stormy conditions
Earth-directed

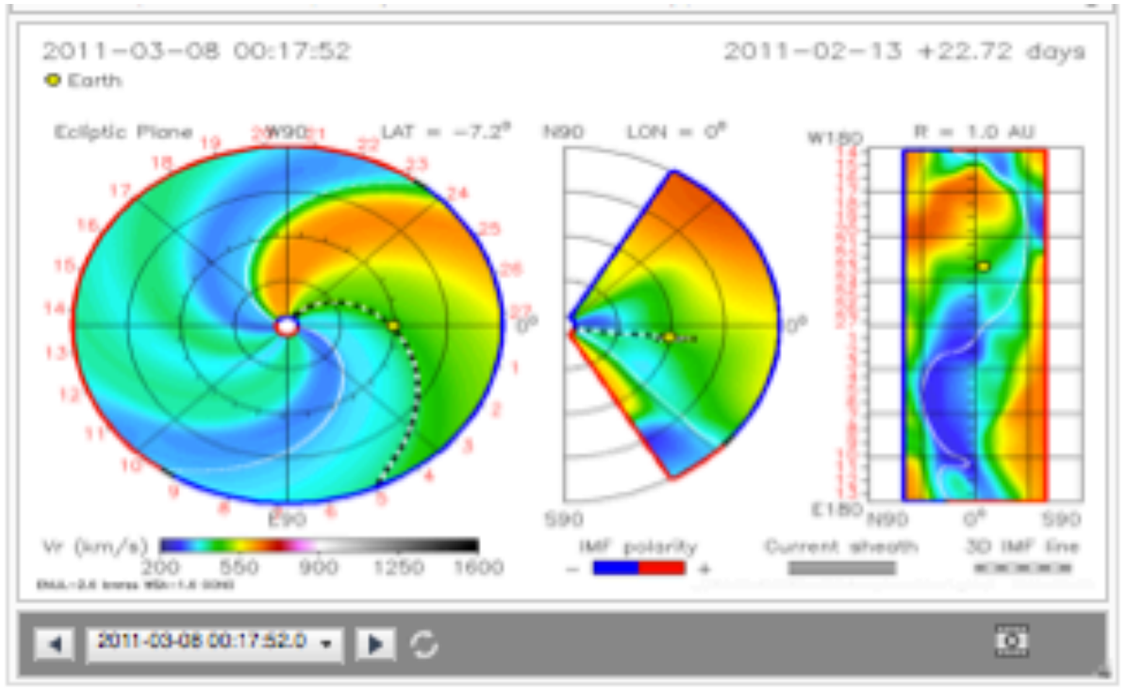


Forecasting capability enabled by WSA+ENLIL



WSA+ENLIL+cone

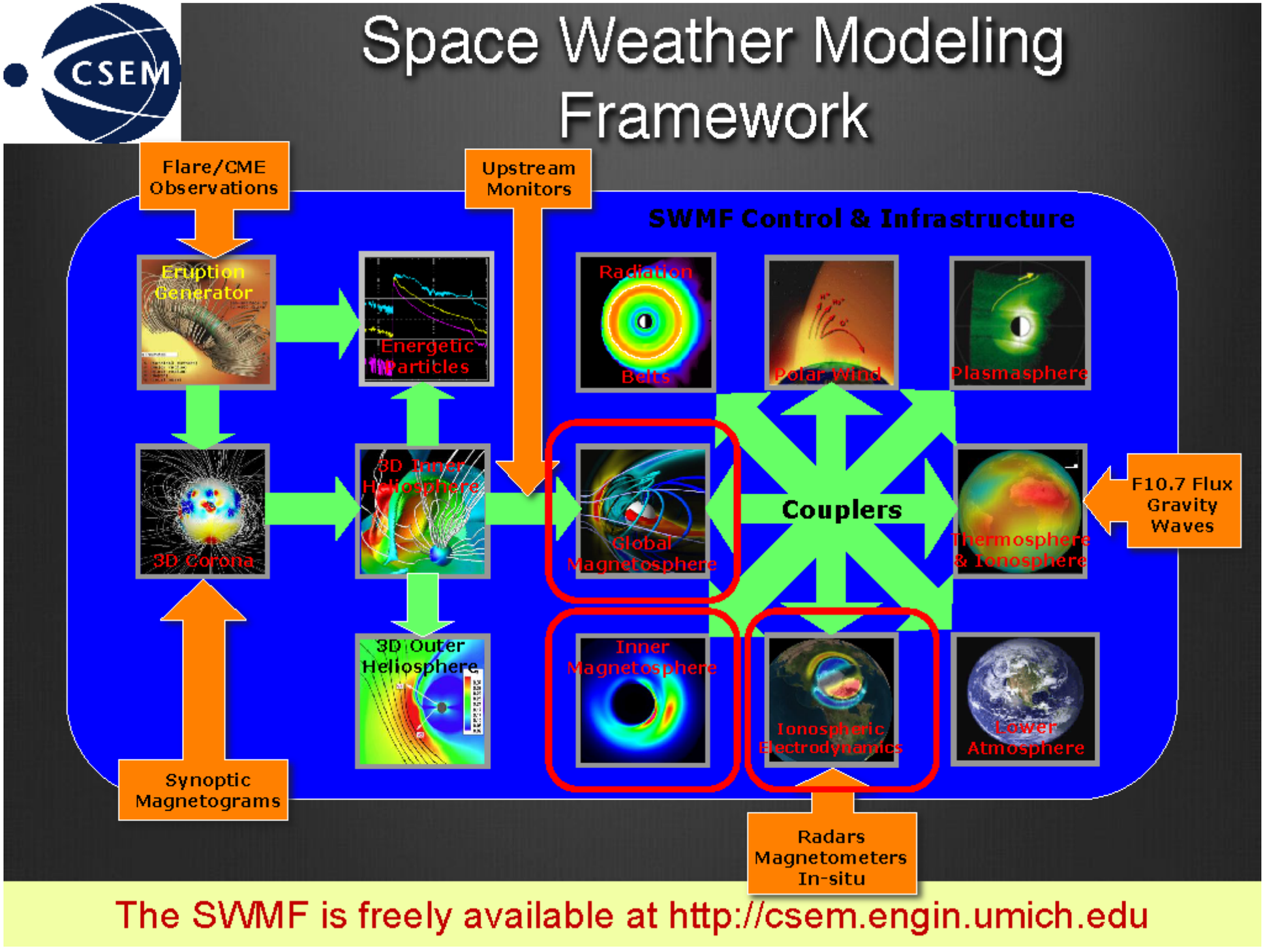
Predicting impacts of CMEs



WSA+ENLIL

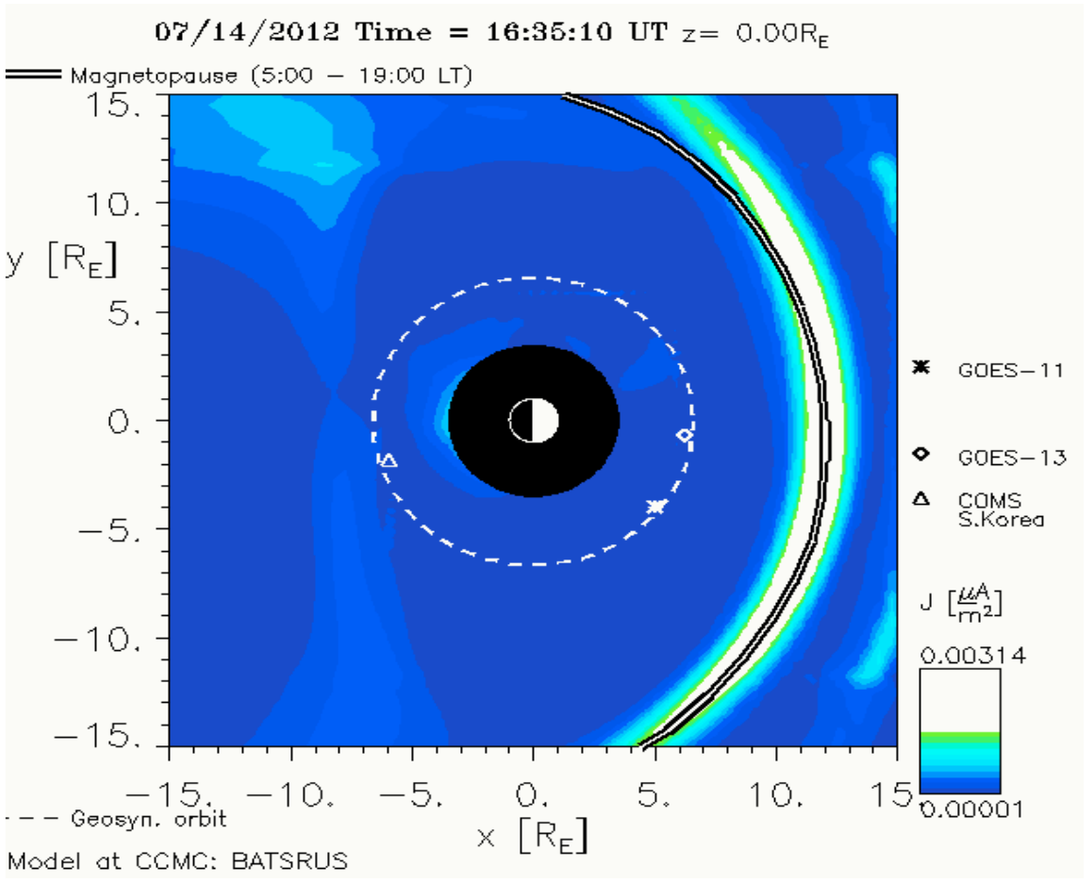
Modeling and predicting the ambient solar wind

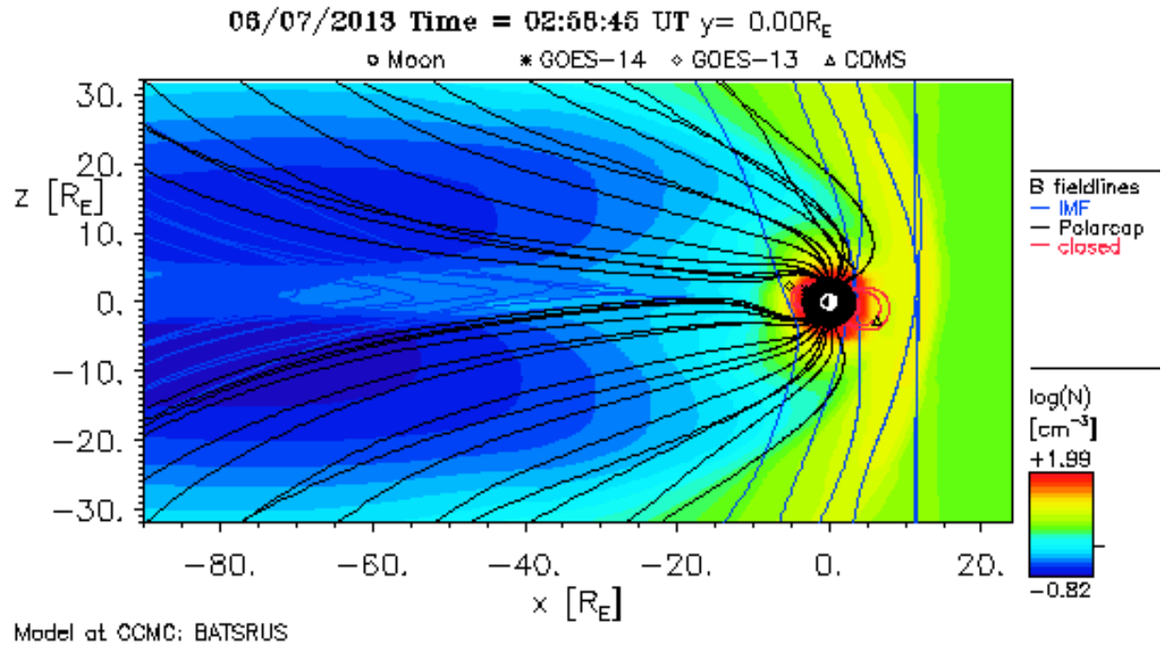
SWMF

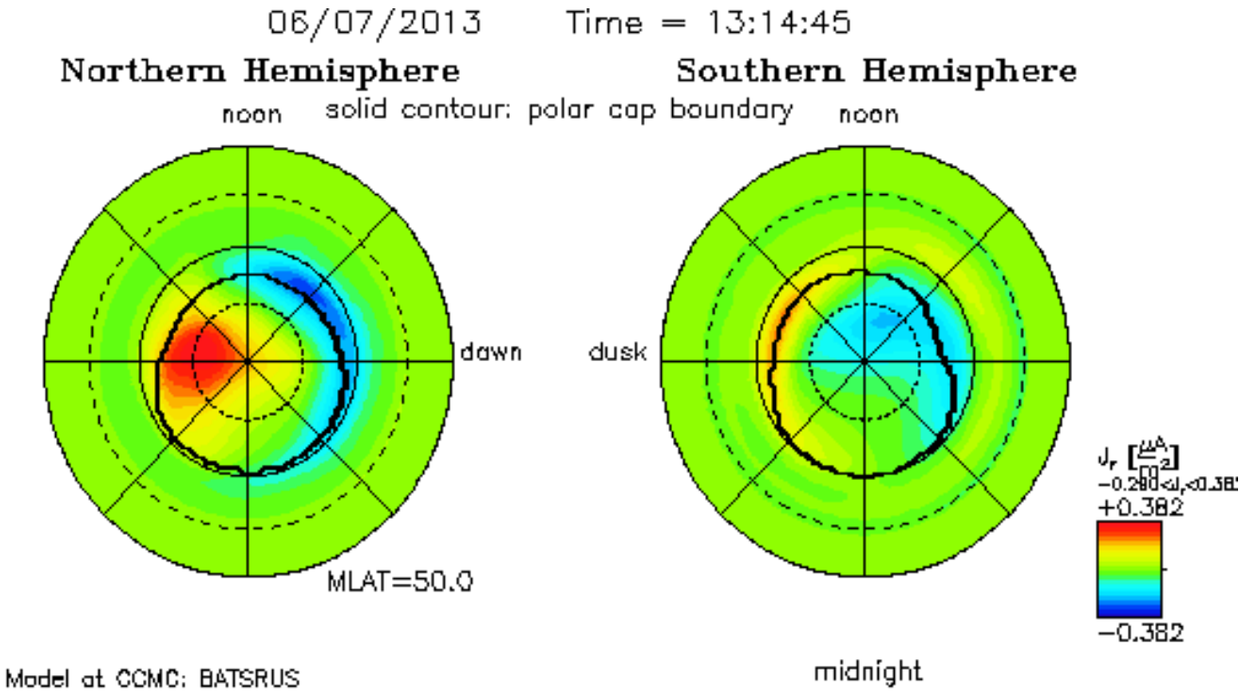


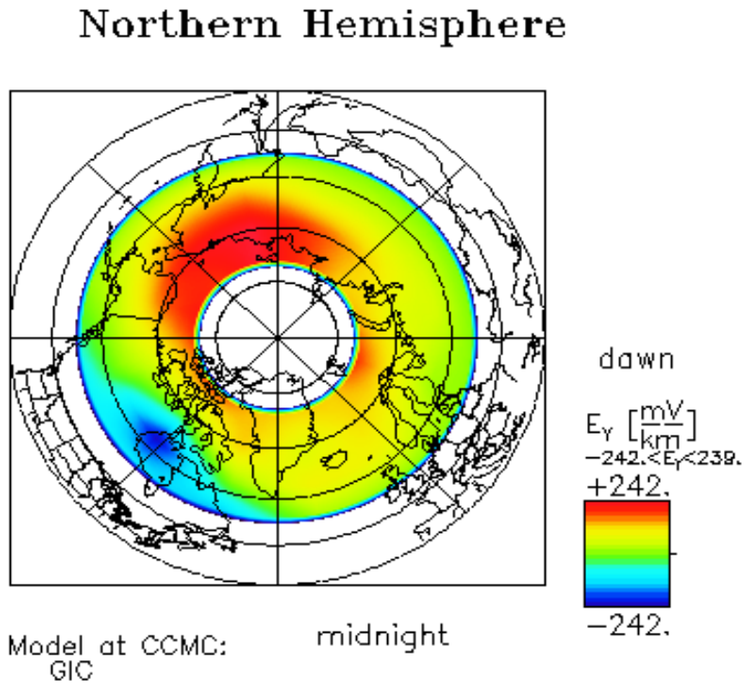
The SWMF is freely available at http://csem.engin.umich.edu

SWMF

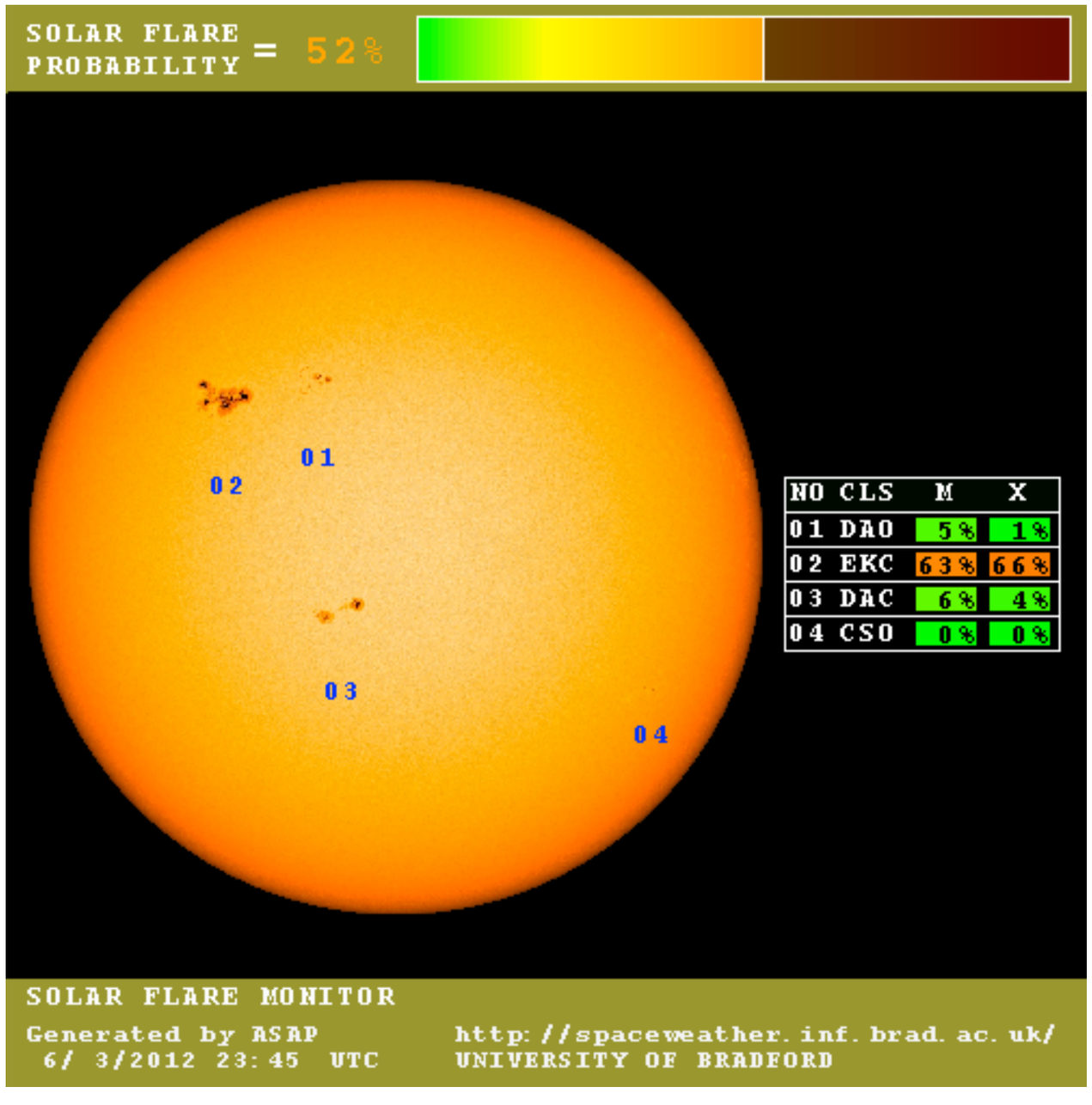

07/14/2012 Time = 16:35:10 UT z= 0.00R_E
Magnetopause (5:00 – 19:00 LT)
15.
10.
y [R_E]
5.
0.
−5.
−10.
−15.
−15. −10. −5. 0. 5. 10. 15.
x [R_E]
GOES−11
GOES−13
COMS S.Korea
J [μA/m²]
0.00314
0.00001
Geosyn. orbit
Model at CCMC: BATSRUS


06/07/2013 Time = 02:58:45 UT y= 0.00R_E
Moon
GOES−14
GOES−13
COMS
30.
20.
z [R_E]
10.
0.
−10.
−20.
−30.
−80. −60. −40. −20. 0. 20.
x [R_E]
B fieldlines
IMF
Polarcap
closed
log(N) [cm⁻³]
+1.99
−0.82
Model at CCMC: BATSRUS

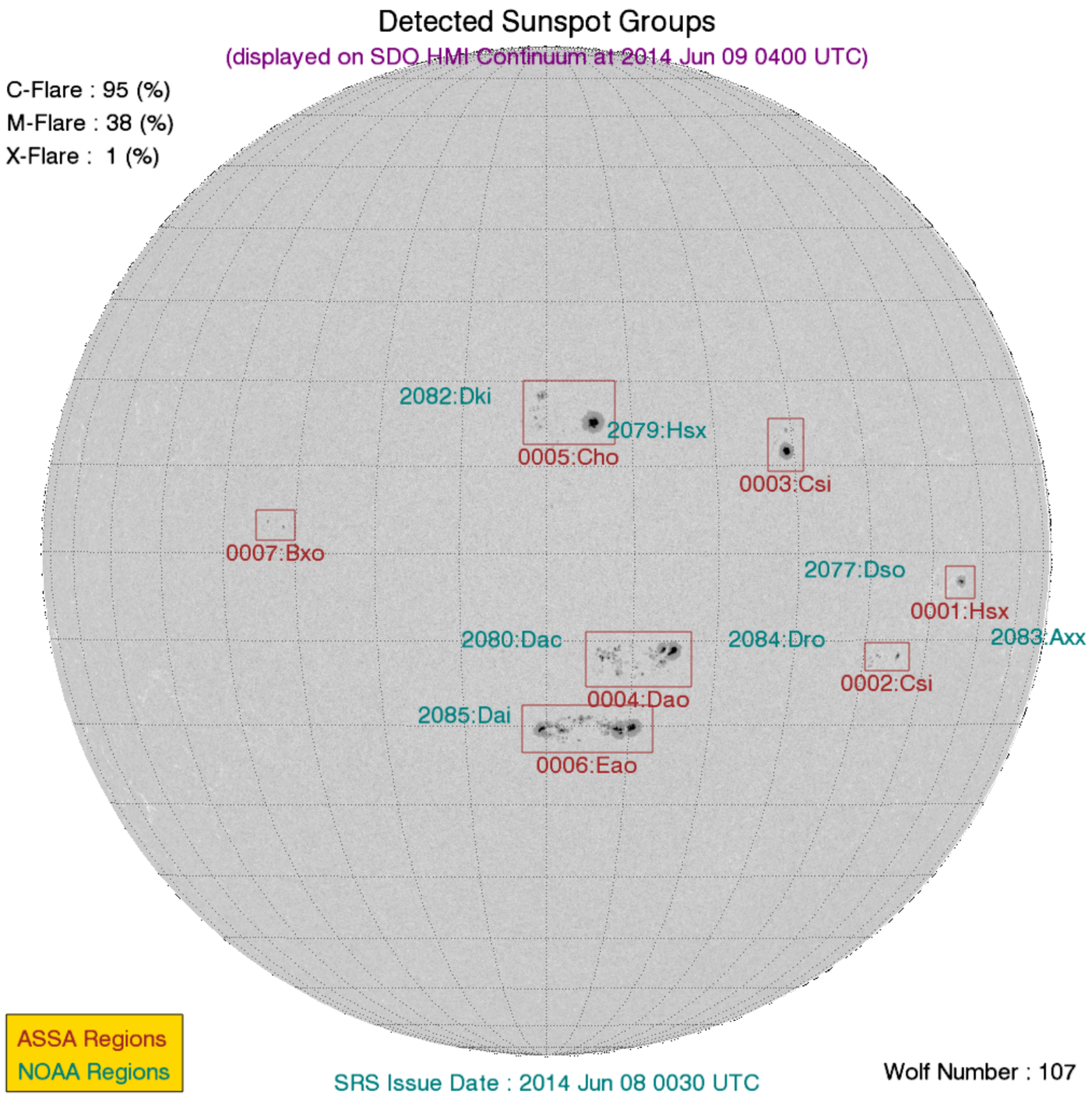

06/07/2013 Time = 13:14:45
Northern Hemisphere
Southern Hemisphere
noon
solid contour: polar cap boundary
noon
dawn
dusk
MLAT=50.0
J_r [μA/m²]
+0.382
−0.382
midnight
Model at CCMC: BATSRUS


06/07/2013 Time = 02:49:55
Northern Hemisphere
dawn
E_Y [mV/km]
+242.
−242.
midnight
Model at CCMC: GIC

Flare Prediction Model
ASAP (Automatic Solar Activity Prediction)
http://spaceweather.inf.brad.ac.uk/asap/



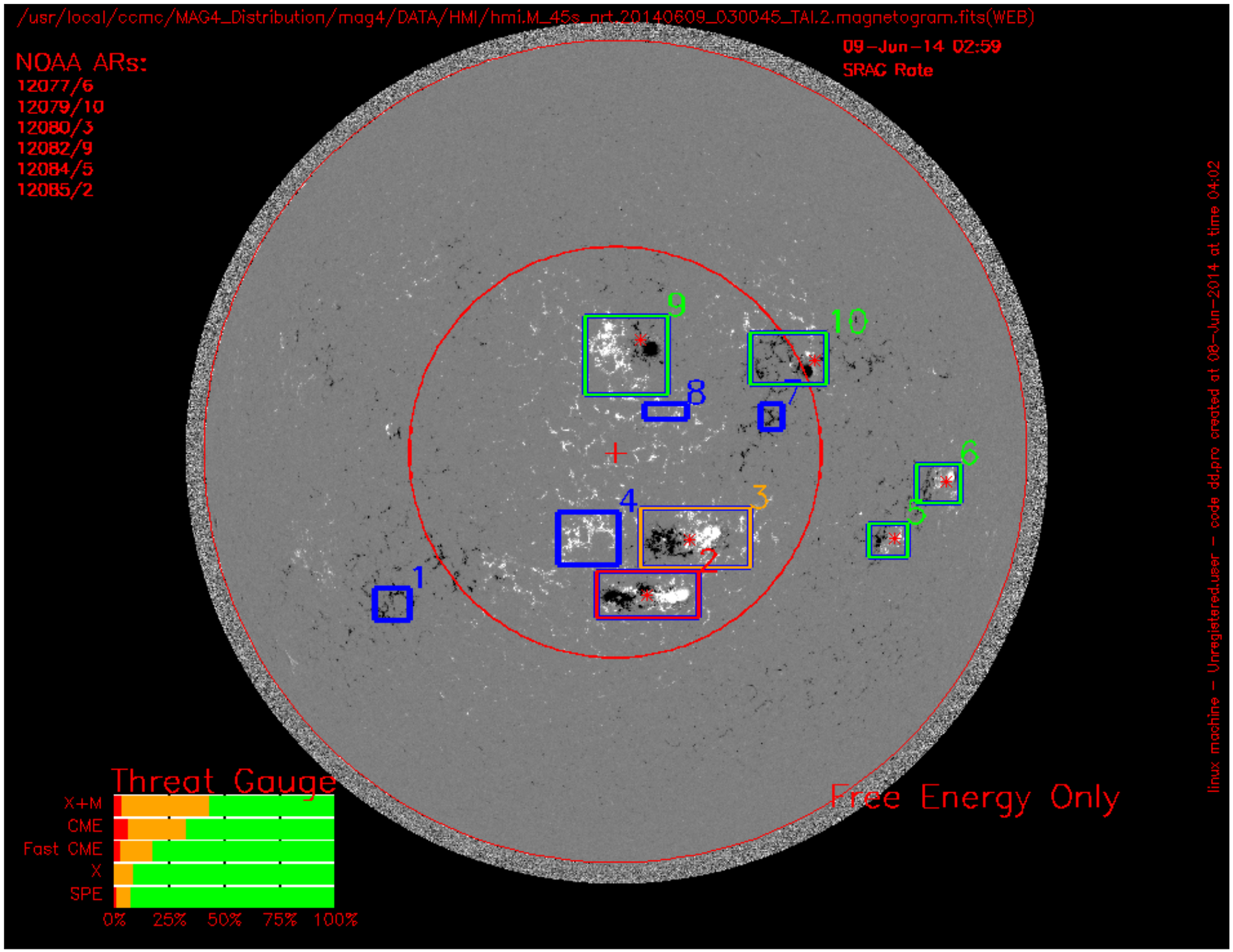
Flare Prediction Model
ASSA (Automatic Solar Synoptic Analyzer)



Provided by

Korean Space Weather Center

Flare Prediction Model
MAG4 (UAH/MSFC, Falconer et al.)



Flare Scoreboard

https://ccmc.gsfc.nasa.gov/challenges/flare.php

Currently registered models and particpating partners:

AMOS Automatic McIntosh-based Occurrence probability of Solar activity Korea Meteorological Administration KYUNG HEE UNIVERSITY	**ASAP** Automated Solar Activity Prediction UNIVERSITY of BRADFORD	**ASSA** Automatic Solar Synoptic Analyzer RRA KOREAN SPACE WEATHER CENTER
BoM Data-driven probabilistic flare forecast model Australian Government Bureau of Meteorology	**MAG4** MAG4 LOS and Vector Magnetogram Forecasts (four products) THE UNIVERSITY OF ALABAMA IN HUNTSVILLE	**Met Office** Space Weather Forecast (full disk) and Sunspot Region Summary Met Office
SIDC SIDC human operator moderated Royal Observatory *of* Belgium	**SolarMonitor.org** Flare Prediction System Trinity College Dublin The University of Dublin	**UFCORIN** Universal Forecast Constructor by Optimized Regression of INputs UFCORIN

Beta Flare Scoreboard Result

https://iswa.gsfc.nasa.gov/IswaSystemWebApp/index.jsp?i_1=606&l_1=7&t_1=33&w_1=1721&h_1=865&s_1=0

SEP prediction
REleASE (Relativistic electron Alert System for Exploration)

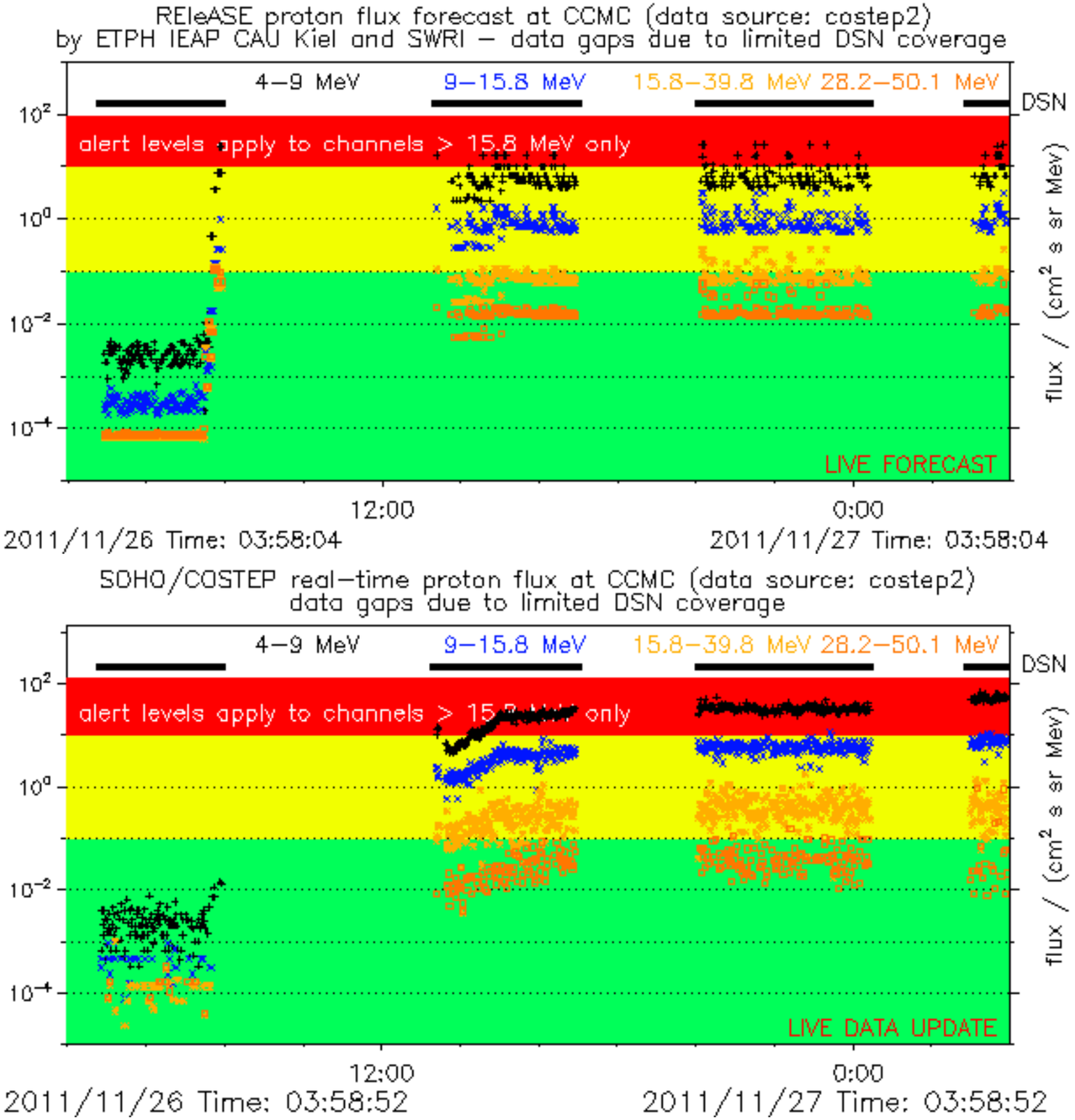
Proton flux forecast model based on electron measurements by SOHO/COSTEP

developed by Arik Posner

Reference: Posner, A. (2007), Up to 1-hour forecasting of radiation hazards from solar energetic ion events with relativistic electrons, Space Weather, 5, S05001, doi:10.1029/2006SW000268.

HESPERIA_REleASE (v20190101)

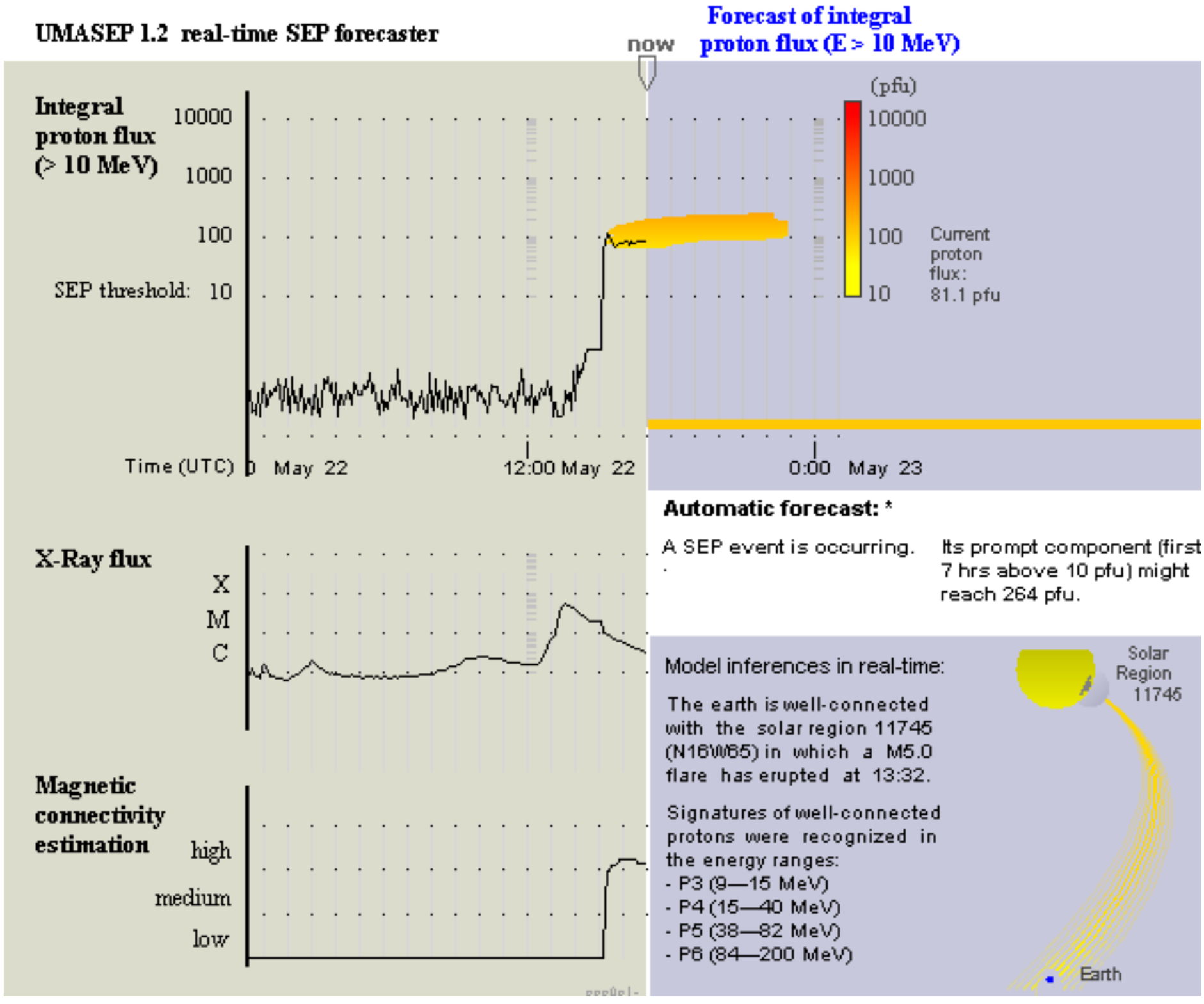
RELeASE: Example



SEP Prediction
UMA Proton Flux Forecast

Núñez, M. (2011), Predicting solar energetic proton events (E > 10 MeV), Space Weather, 9, S07003, doi 10.1029/2010SW000640.

UMASEP Model



ISEP & SEP Scoreboard

https://kahala2.ccmc.gsfc.nasa.gov/isep/

Models

HESPERIA REleASE High Energy Solar Particle Events foRecastIng and Analysis Relativistic Electron Alert System for Exploration	**UMASEP-10 & 100** **HESPERIA UMASEP-500** University of Malaga Solar energetic proton Event Predictor	**SEPSTER** SEP predictions inspired by STEReo
STAT SPE Threat Assessment Tool (CORHEL+EPREM)	**MAG4** Magnetogram Forecast	**SEPMOD** SEP MODel

ISEP & SEP Scoreboard

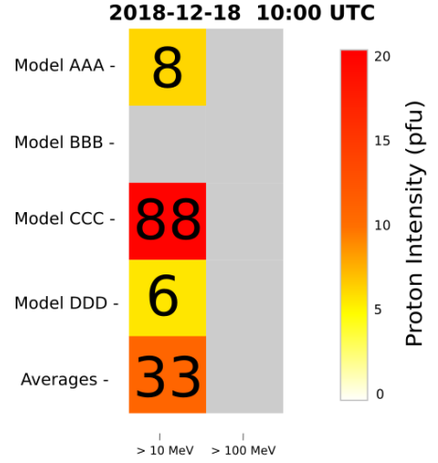
https://kahala2.ccmc.gsfc.nasa.gov/isep/

SEP Scoreboard

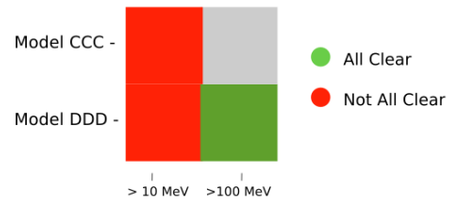
Proton Intensity Forecast

2018-12-18 10:00

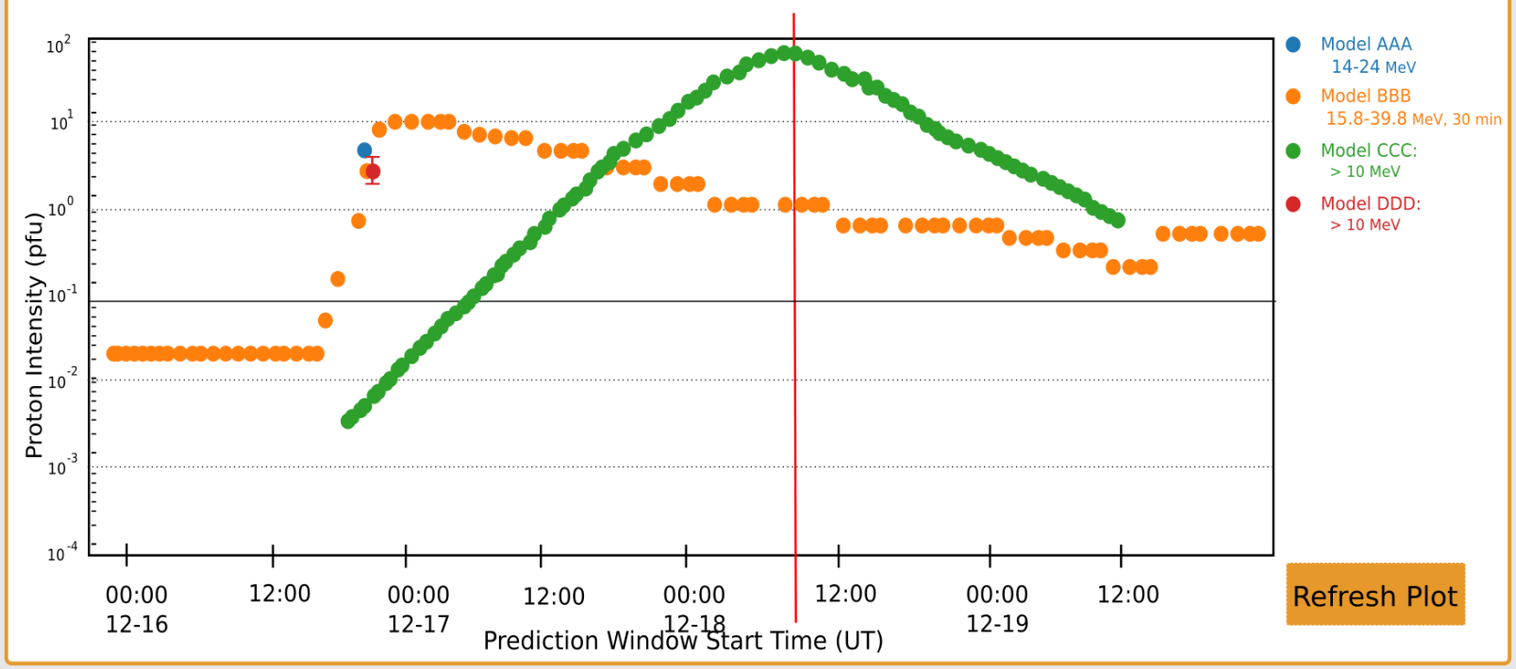
Peak Intensity Forecasts:
2018-12-18 10:00 UTC



All Clear Forecasts:
2018-12-18 10:00 UTC



Download Data

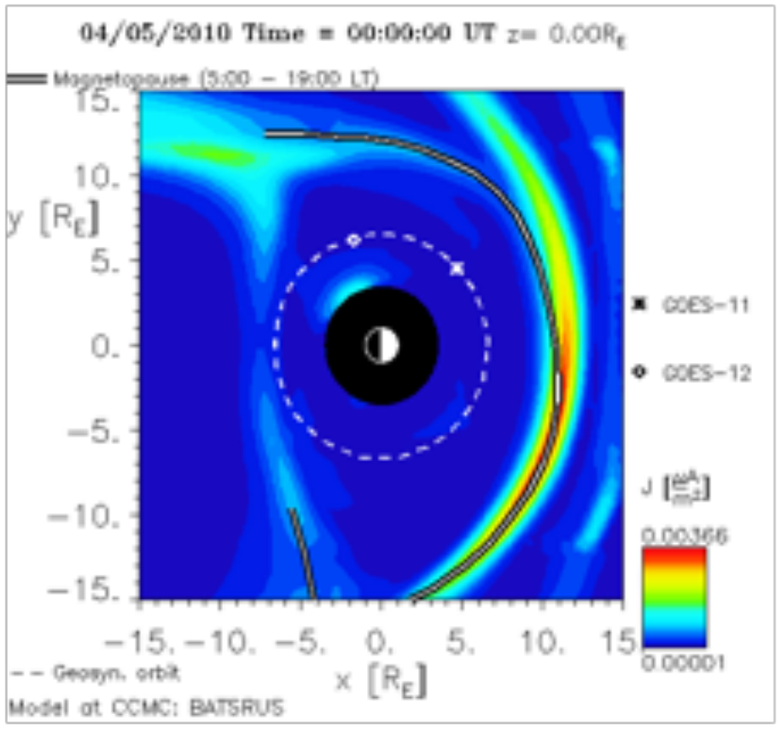


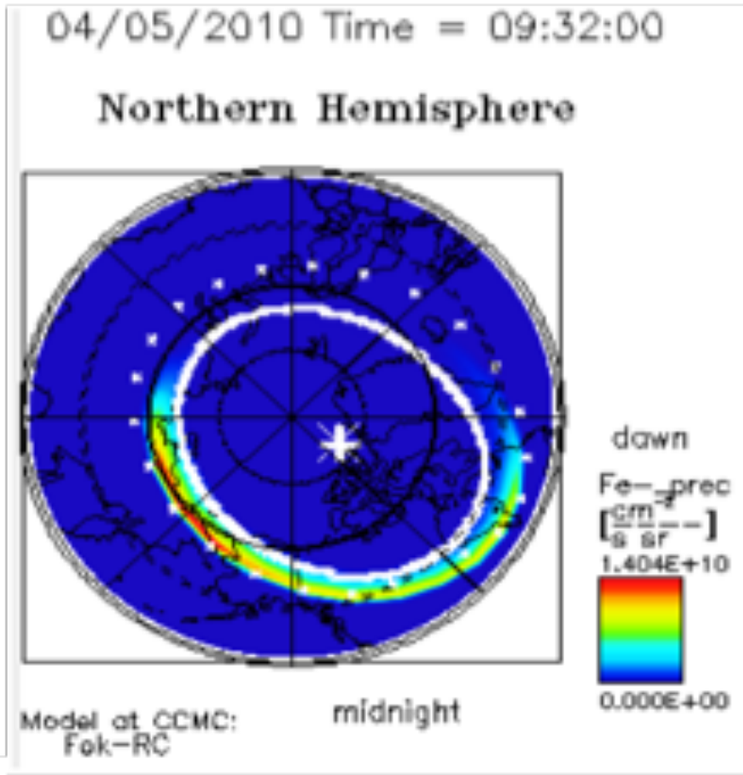
Models

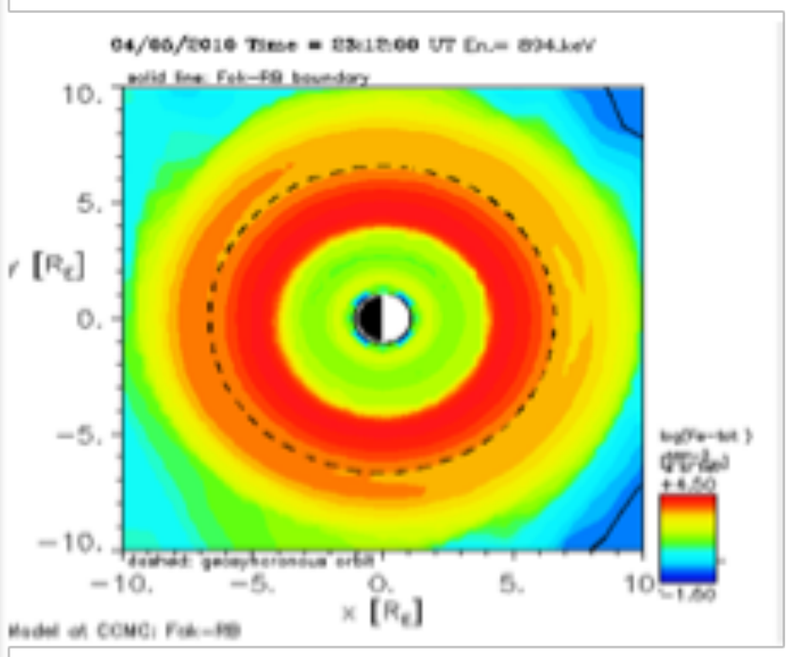
- **Model AAA**
  - > 10 MeV
  - 14-24 MeV
- **Model BBB**
  - 15.8-39.8 MeV
    - 30 minutes
    - 60 minutes
    - 90 minutes
  - 28.2-50.1 MeV
    - 30 minutes
    - 60 minutes
    - 90 minutes
- **Model CCC**
  - > 10 MeV
  - > 30 MeV
  - > 50 MeV
  - > 60 MeV
  - > 100 MeV
  - > 300 MeV
- **Model DDD**
  - > 10 MeV
  - > 100 MeV
  - > 500 MeV
- **Model EEE**
  - > 100 MeV

Examples of April 5 events

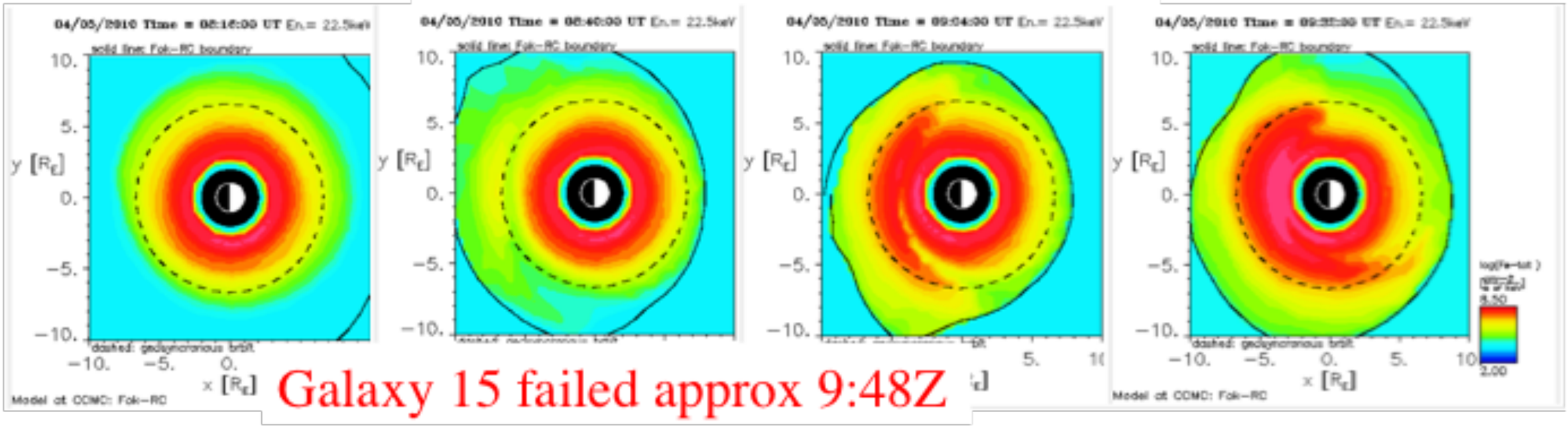
SWMF + Fok Ring Current Model





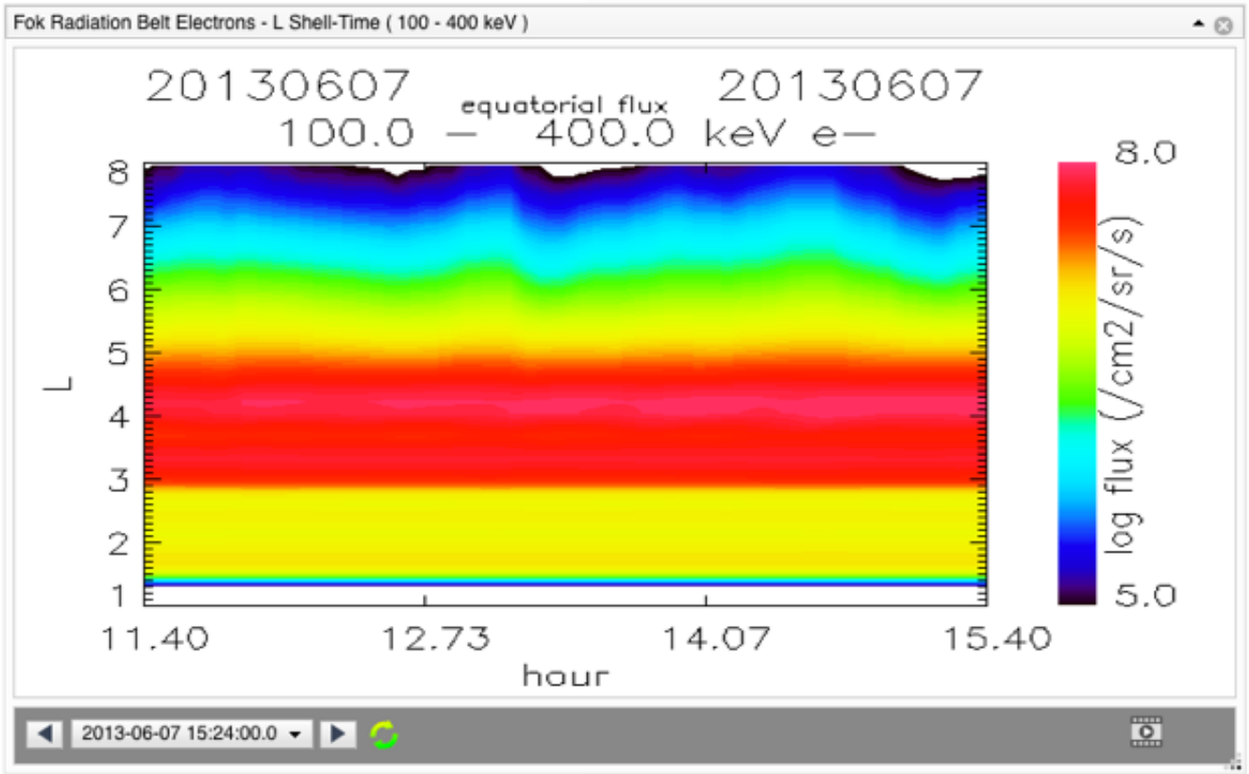


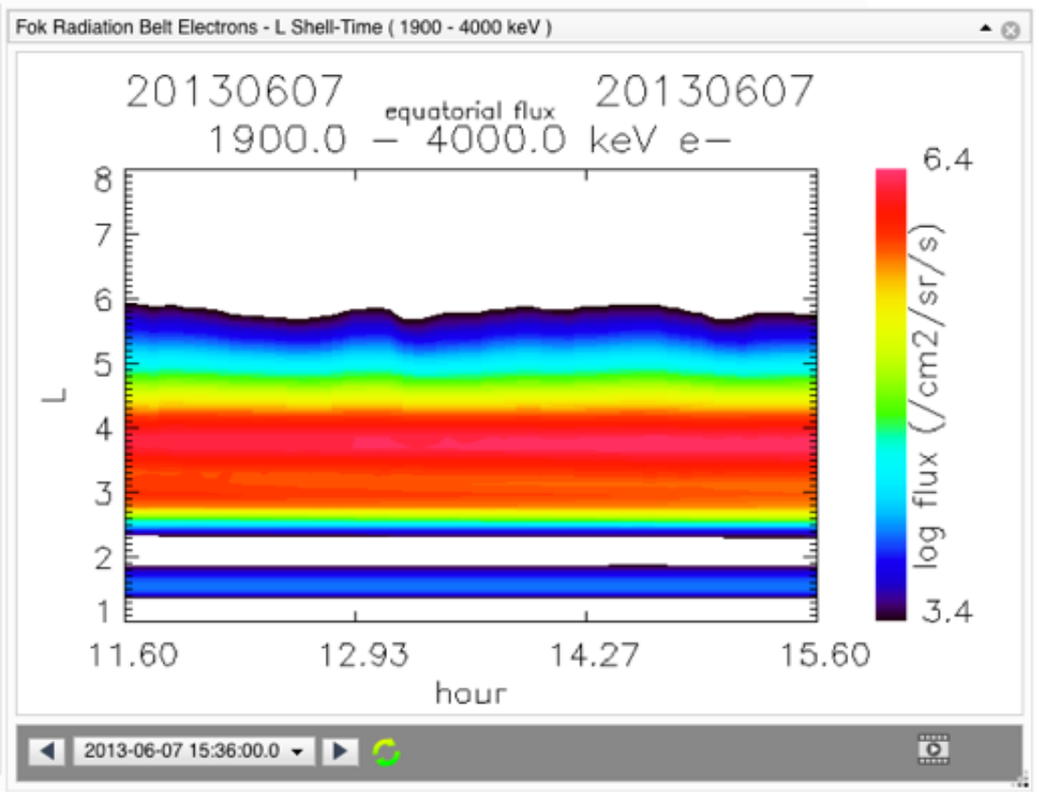
22keV electrons 4/5, 8:16-9:32Z

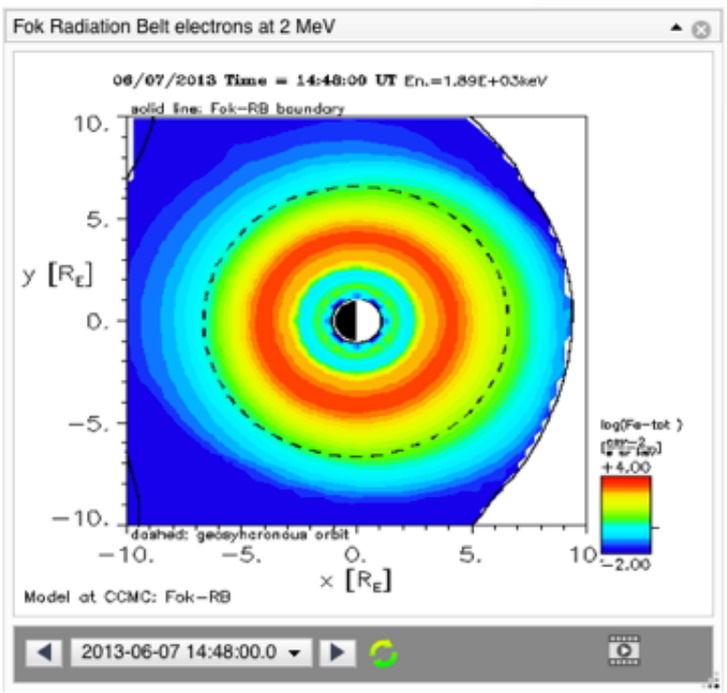


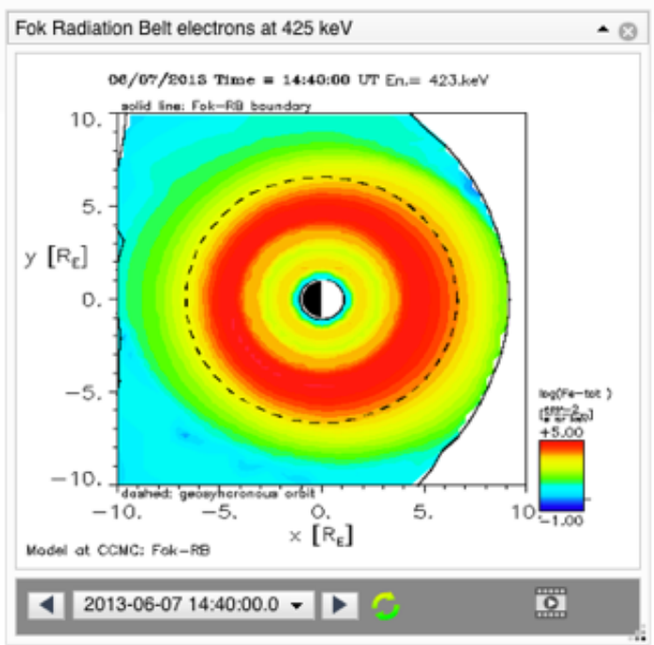
Galaxy 15 failed approx 9:48Z

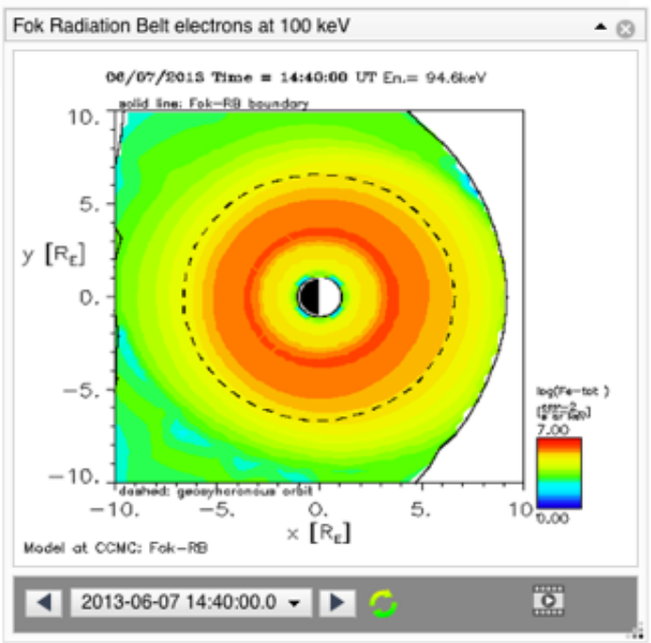
Fok Radiation Belt Model



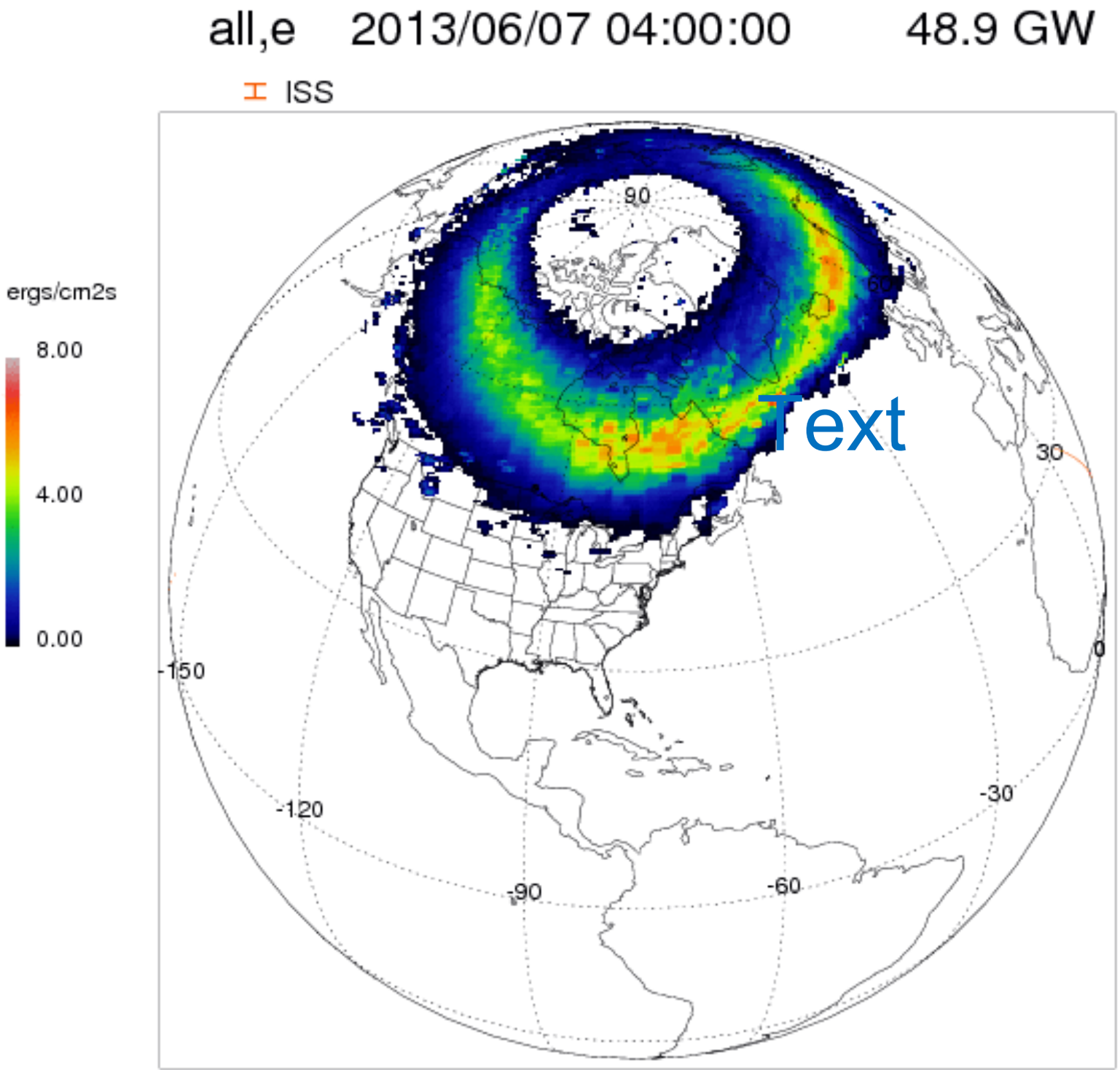








Auroral Model: Ovation Prime

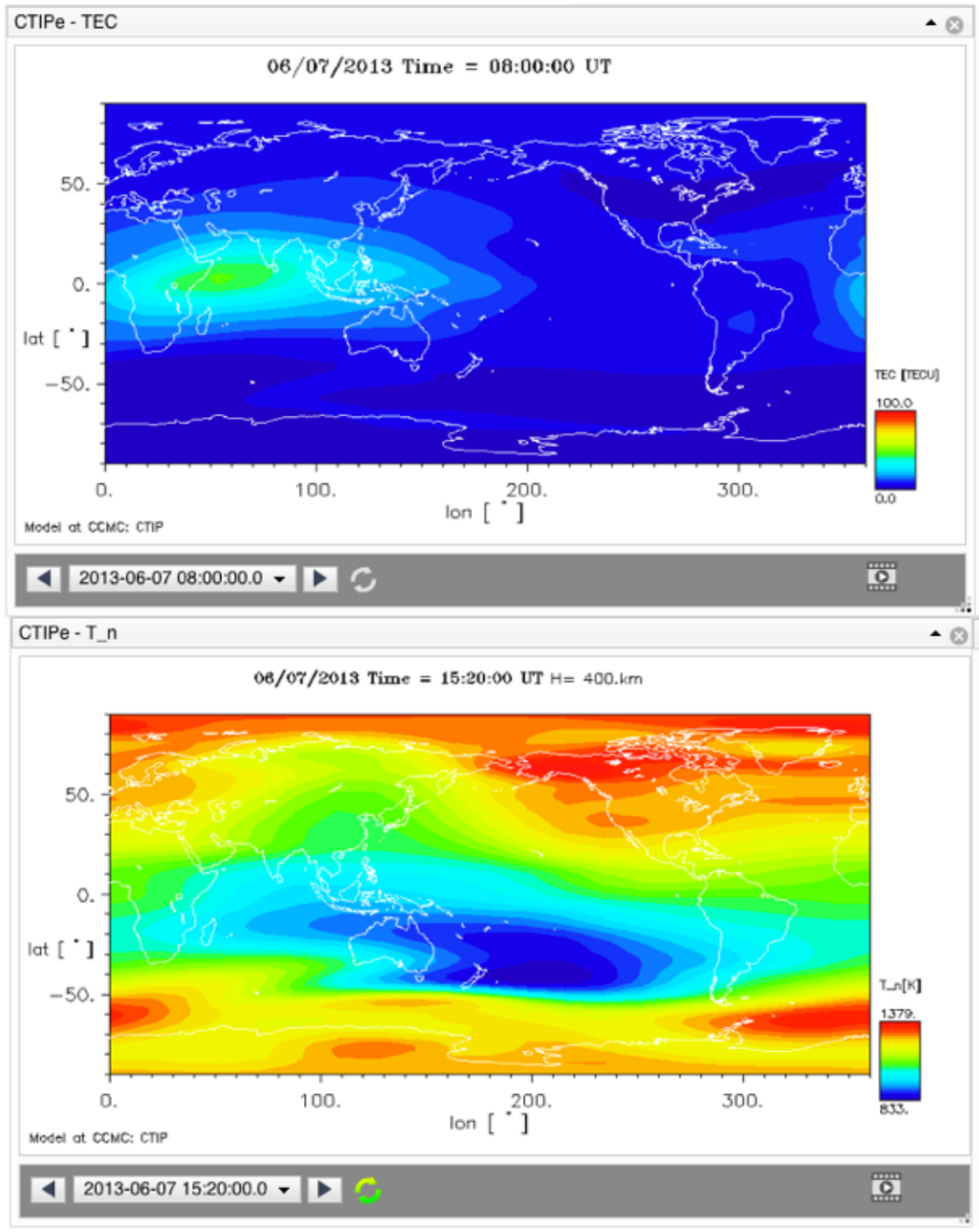


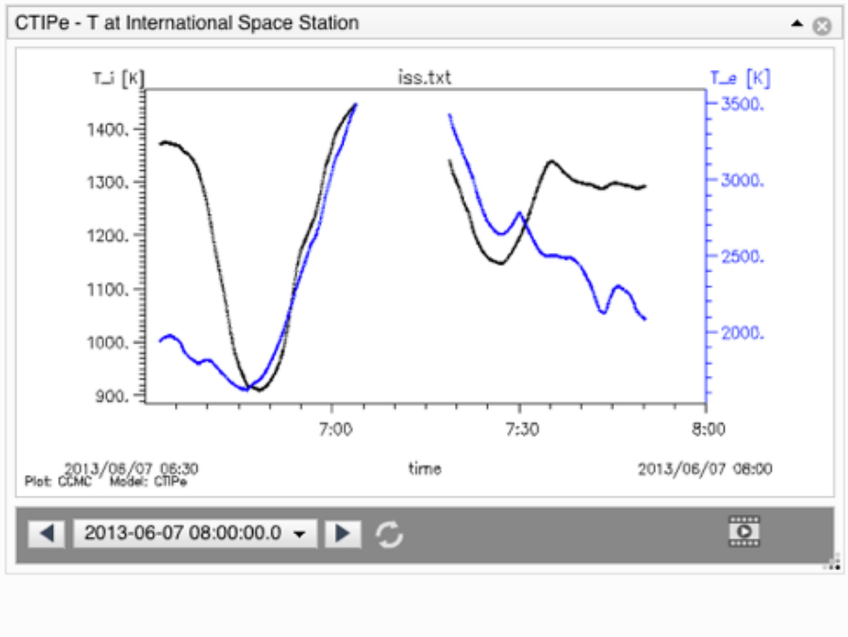
Empirical model based on ACE measurements at L1

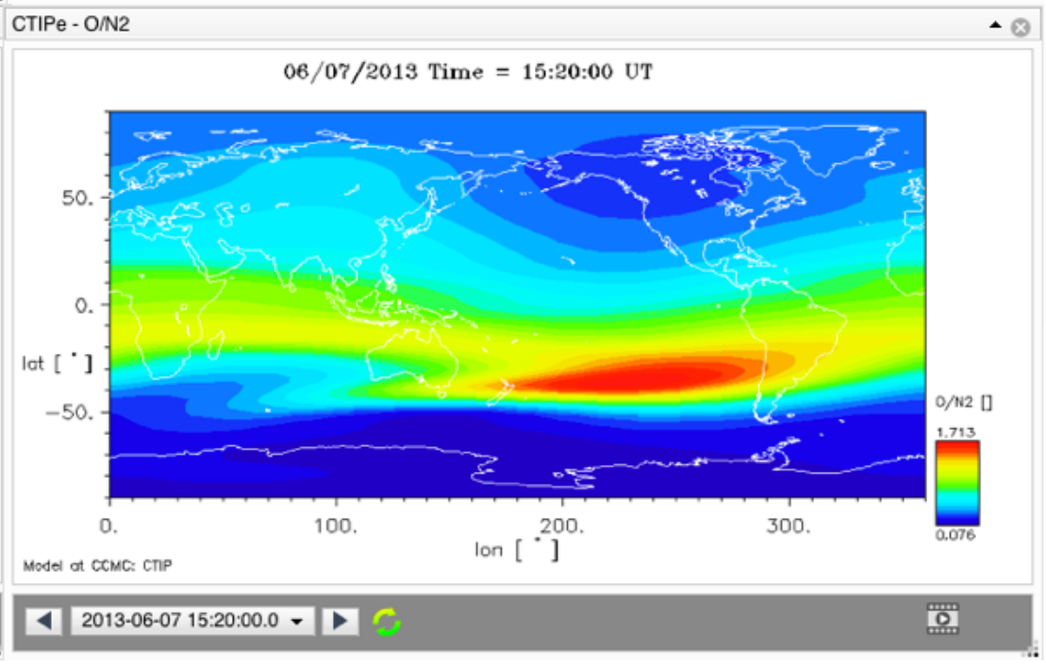
Newell et al., 2007, JGR

CTIPe

Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model

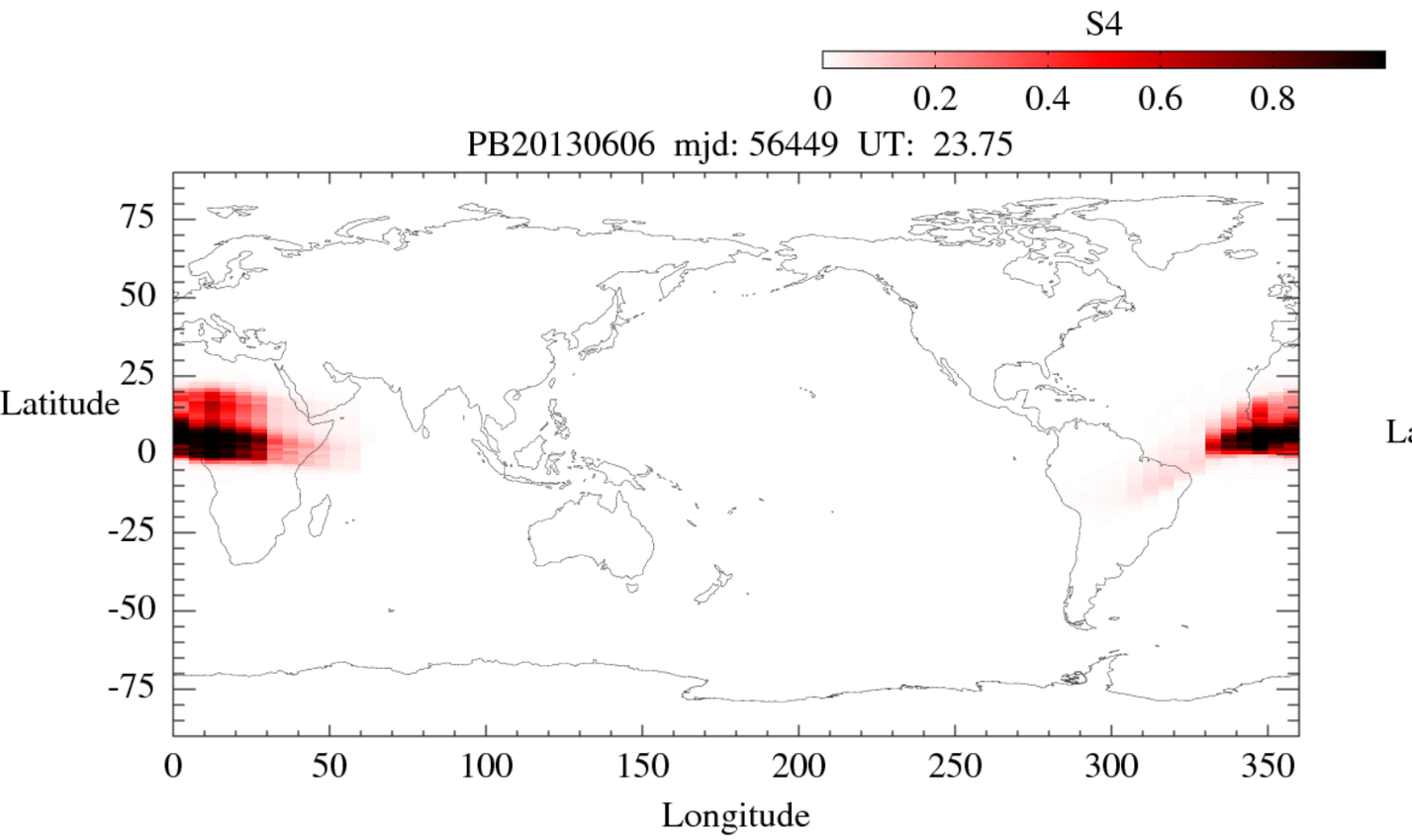


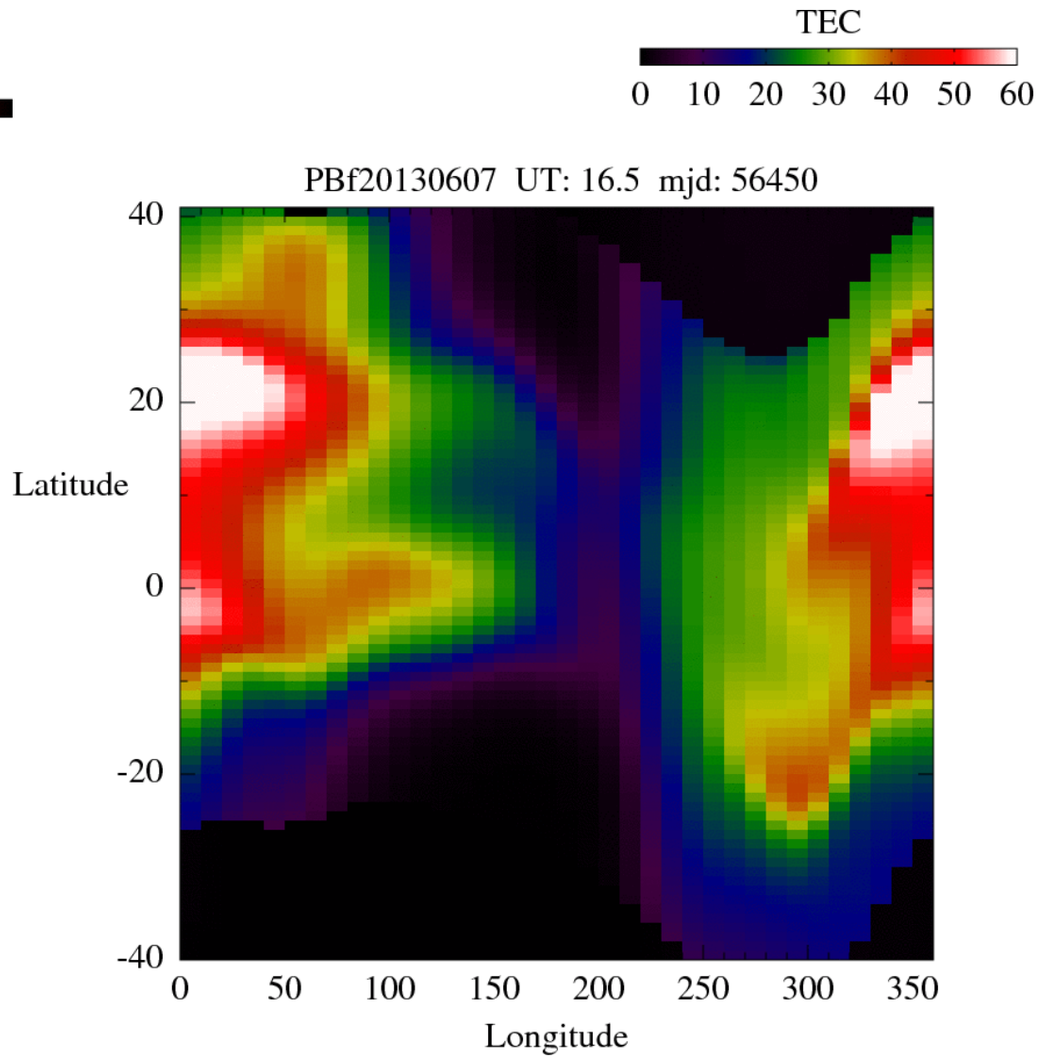




PBMOD
Scintillation Model

http://ccmc.gsfc.nasa.gov/RoR_WWW/pbmod-rt/PBMOD-Text.html

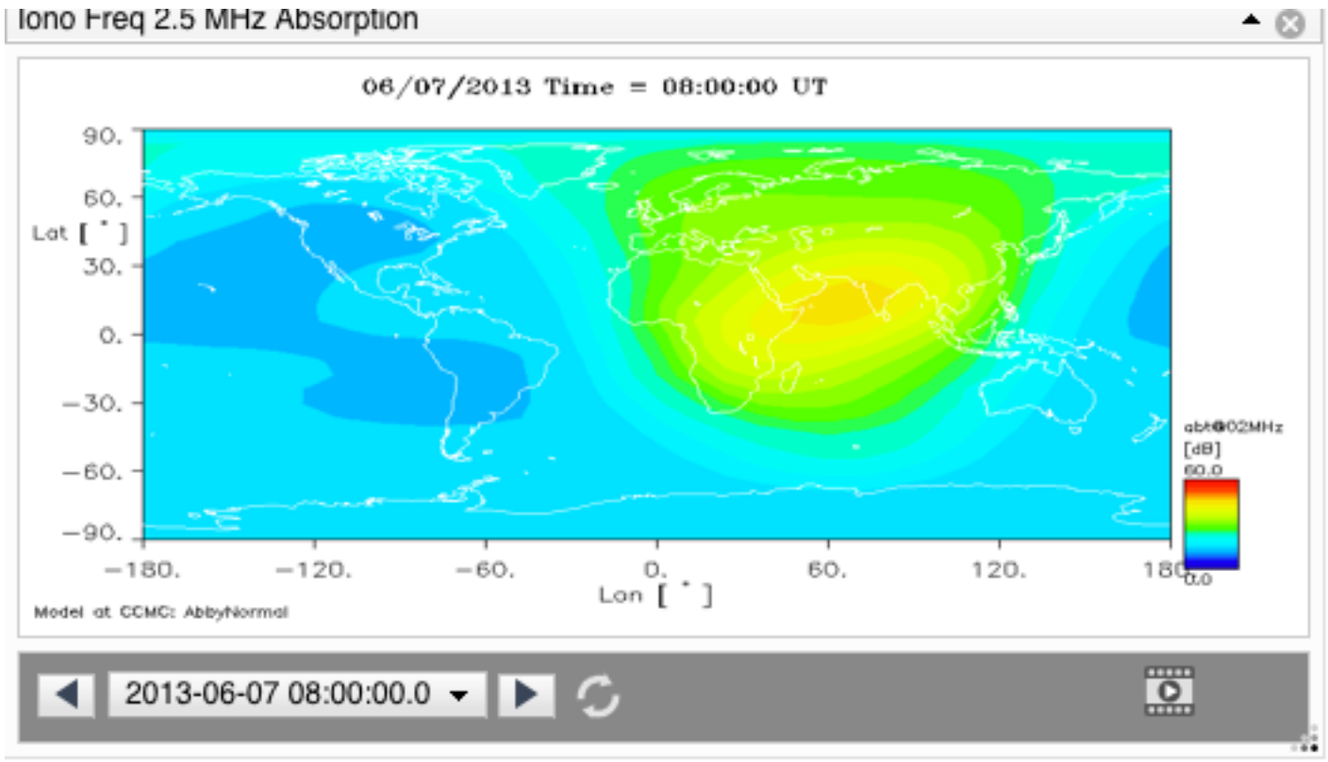


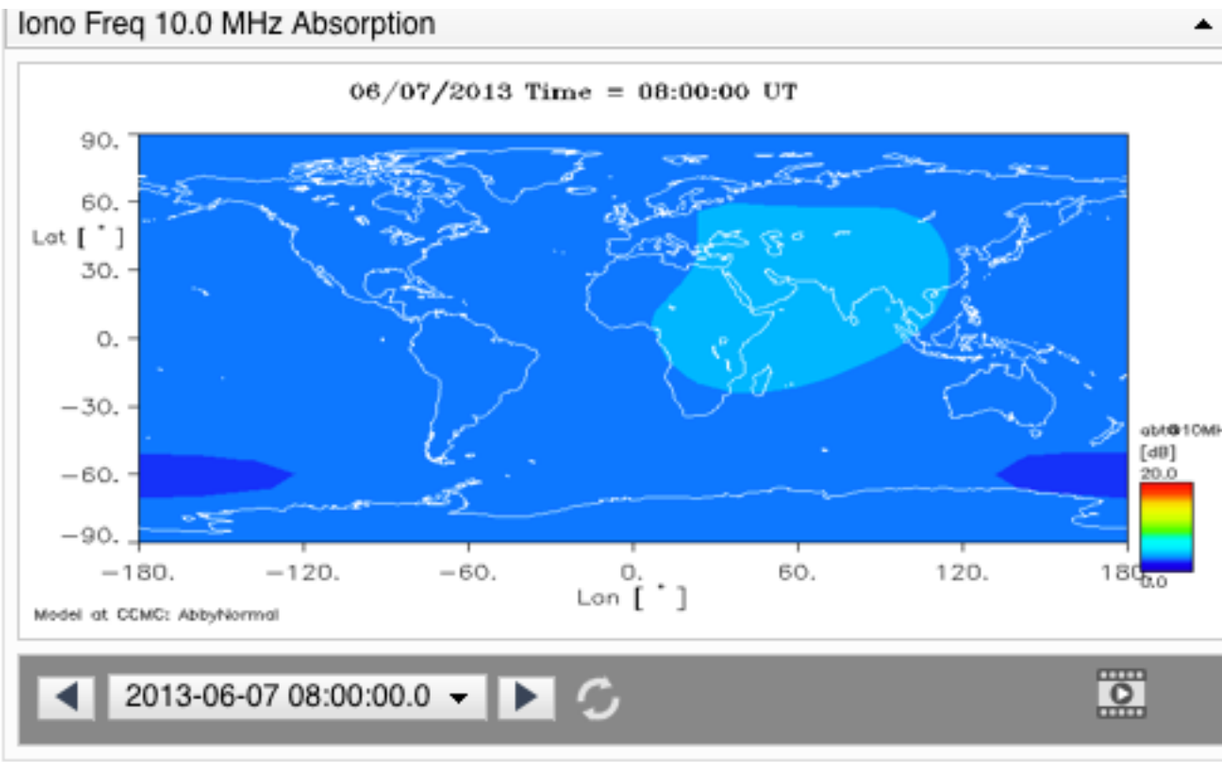


Physics Based MODels - Time-Dependent Model of The Global Low-Latitude Ionosphere, Plasma Irregularities, and Radio Scintillation

ABBYNormal
HF Signal Absorption due to Solar Flares

http://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=ABBYNormal





Predicted Kp, Dst

Kp based on Newell et al. Formula
Dst from SWMF
Dst from WINDMI

http://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=WINDMI